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Some of the Flood-Control Aspects of Farm Ponds — *Austin W. Zingg*

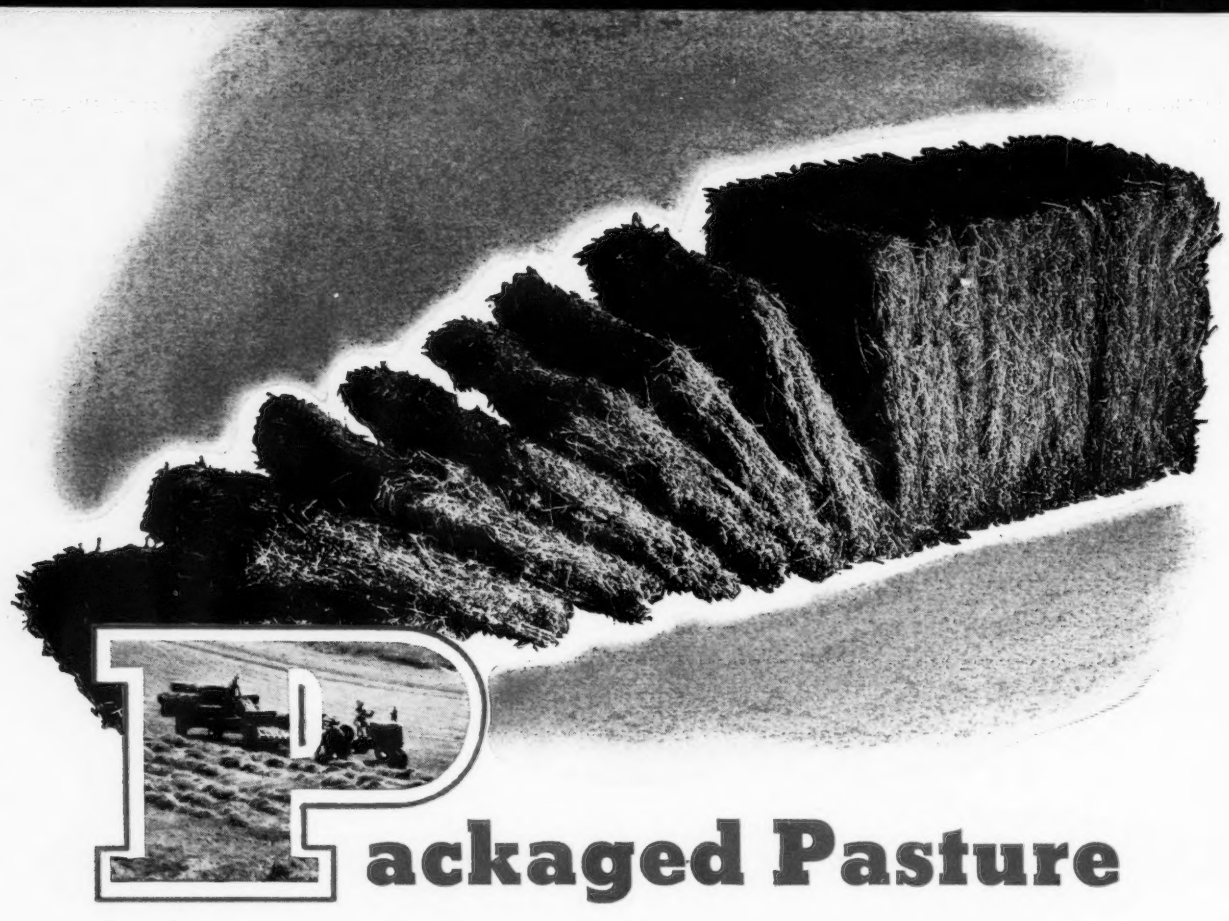
The Mechanical Features of Farm Dehydrators — *Ben D. Moses*

The Water and Thermal Relationships in Soils — *Robert G. White*

Application of Stream Gaging to Small Streams and Ponds — *M. T. Thomson*

Imagineering—Radiation on the Farm of Tomorrow — *L. C. Porter, G. F. Prideaux*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS



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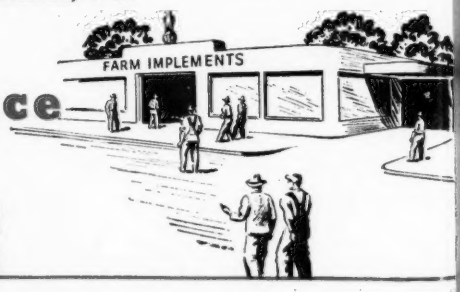

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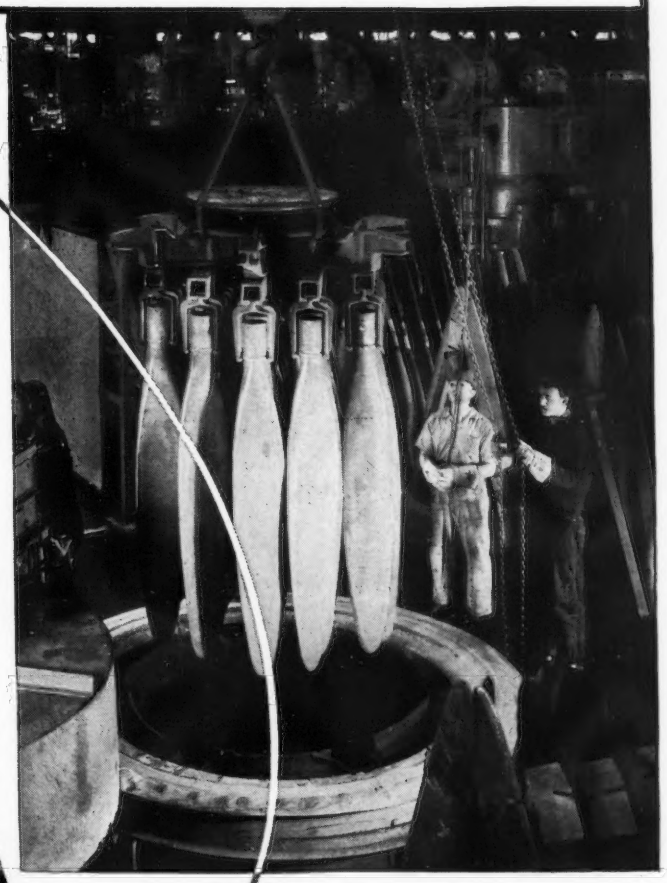

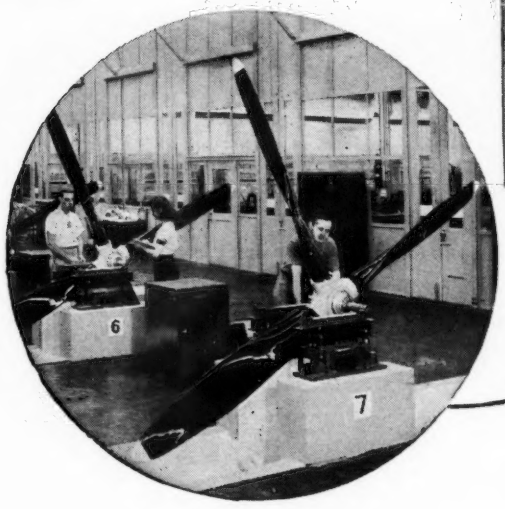

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AGRICULTURAL ENGINEERING

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Most farms lie somewhere between the extremes shown in these two photographs. The condition portrayed by the lower photo can be attained and that shown by the top one avoided by good maintenance planning . . . carefully thought out in January and consistently followed through during late winter and early spring, before the heavy work of the farm production year starts.

Now is the time to survey foundations, sidewalls, interiors, frames and roofs, so that essential repair work can be scheduled intelligently.

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Southern Farmhouse of Plywood Construction

Rendering NHF Plan F1S.
National Homes Foundation southern farmhouse Plan F1S.

The National Homes Foundation, an informal organization of federal housing agencies and commercial concerns supplying building materials and equipment, selected a group of eight house plans suitable for urban and farm living under northern and southern conditions.

This plan shows one of the southern farm home designs constructed of Douglas fir plywood. The result is a comfortable farm home of typical southern architecture with the advantages of a modern material.

Its small size and inexpensive construction makes it desirable for small acreages, or for a second house on the farm when a soldier son returns to assume active management.

CONSTRUCTION SUGGESTIONS

FOUNDATION—Follow standard practice.

FRAMING—Conventional.

SUB-FLOOR—Desirable to check air infiltration and prevent cold floors. For 13/16" wood flooring use 5/16" PLYSCORD lengthwise across joists. Nail flooring to each joist. For linoleum use 5/8" PLYSCORD across joists with 2"x4" headers cut between joists at panel joints. Cement felt and linoleum to sub-floors. (Where linoleum-floored areas open into wood-floored rooms, use ¾" panel under former to maintain even floor level.) Sound-one-side grade EXTERIOR type panels properly finished with penetrating floor seal or floor enamel make attractive finish floors for bedrooms or other "secondary" rooms. Use 3/8" thickness over sheathing or ½" thickness on floor joists spaced 16" o.c.

INTERIOR WALLS AND CEILINGS—PLYWALL panels ¼" thick are adequate, but 3/8" thickness is recommended for greater ease in obtaining true surfaces. For paneled effects lay out panel design and apply first panels at centers of areas, using V-joints or battens. Panels may be placed vertically or horizontally; battens may be either surface or inset mouldings. For smooth wall effect nail ¼" x 2¼" plywood furring strips to framing and glue panels to these. Cut in headers where necessary to support all panel edges.

INTERIOR TRIM—For clean, modern effect fit plywood accurately to casings at openings and bull-nose edges, or use narrow wood mouldings or narrow strips of ¼" plywood as trim. Use 4" or 6" strips of ¼" plywood with wood quarter-round as base mouldings.

EXTERIOR WALLS—Use router to cut V-grooves through face veneer of 3/8" (or ½") EXTERIOR type Douglas fir plywood panels for desired paneling effect. Coat all edges of panels with heavy white lead paint and apply horizontally over studs. Cut in headers to back-up all panel edges. Nail with 6d galvanized box nails, spaced 6" at edges and 12" elsewhere. All horizontal joints must be flashed with Z-shaped metal flashings or carefully filled with paintable mastic.

INSULATION—Apply thermal insulation above ceilings in thickness recommended for climate.

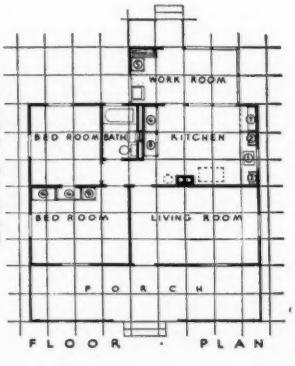
ROOF—Apply 5/16" PLYSCORD sheathing across rafters having maximum spacing of 20". Protect PLYSCORD at all roof edges with wood verge or trim strips. (Note continuous screened air inlet along eave for attic ventilation. Cover roof with V-crimp or other architecturally acceptable style of galvanized metal roofing.

INTERIOR WALL AND CEILING FINISH—For panelled effects use stain, flat wall paint or enamel, or plastic paint on plywood surfaces. For smooth walls use flat wall paint or enamel, plastic paint, canvas painted or wallpaper. For the latter, apply prime coat of paint to plywood, then smooth-surfaced building felt, and then wallpaper.

EXTERIOR WALL FINISH — Prime coat with raw linseed oil carrying moderate amount of pigment, and complete with standard mixed exterior paint of proven durability for local climate. In damp localities back-prime EXTERIOR siding.

Wall section. (lefthand side P. 9 of booklet). Typical exterior wall section showing the placement of the different types, grades, and thicknesses of fir plywood recommended for southern houses. This construction is accepted by FHA.

Complete working drawings and material list of this design may be purchased through your lumber dealer from National Plan Service, Chicago, Illinois. A key plan booklet illustrating and describing the design in greater detail is available from the Douglas Fir Plywood Association.



FLOOR PLAN

Floor Plan.
The floor plan is laid out on a four-foot module to facilitate the architectural planning and the economical use of the plywood panels. Legend: 1, kitchen sink; 2, kitchen casework of plywood; 5, 6, 7, 8, 9, closets and storage units of non-structural, single-wall plywood construction.

Douglas Fir Plywood Association
Tacoma 2, Washington

EDITORIAL

Equities in Ponds

SOMEWHAT superficial consideration of the paper by Austin W. Zing, appearing as the leading article in this issue, indicates that it has far-reaching implications. We hope that not only agricultural engineers but economists and others concerned with agricultural policy share our desire for further study and discussions of this paper and of the whole subject wherein it makes a brave beginning.

Within its cautiously defined limits, this paper attempts to appraise the value of farm ponds for flood control. It indicates that only a very small part of the cost of an "ordinary" farm pond can properly be charged to flood-control benefits. It seems to indicate that all of the relatively small added cost for converting such ponds into the "retarding" type may be economic. But economic for whom?

The land or other property protected, more or less, from flood damage is downstream, remote from the land whereon the pond is built. How can the pond-builder be fairly reimbursed for the increment of cost required to make his pond effective in protecting the man downstream? How can the latter be enabled, perhaps required, to pay fairly for the flood-control benefits which he gets?

Too obvious and too easy is the answer that farm ponds be subsidized from a governmental treasury. Actually the man subsidized is not the pond-owner, who merely is reimbursed, but the man downstream who may build a barn or a warehouse where nothing belongs but a duck-shooting blind. He, not the taxpayer at large, should pay for his equity in the pond upstream.

Temptation to turn toward government is abetted by the fact that, at least in the present example, the flood-control increment appears economic only at an interest rate so low that it seldom is available except to a strong government. This means that the taxpayer at large pledges his resources to pay out on a project regardless of its prospects for solvency.

Not only with ponds, but with all improvements where the costs and the benefits are so widely separated, the temptation to draw on government should be resisted. Every effort should be made to collect investment charges from the beneficiaries. Admittedly there are immense complications of detail and of computation in such a policy. But there is a fund of methodology at hand, as in the experience of irrigation districts.

Indeed, it is implicit, from the fact that the present study appraises the benefits of ponds as flood-control devices, that such benefits can be and have been estimated. If they can be estimated with reasonable accuracy, it follows that they can be assessed with reasonable fairness, and the proceeds likewise reflected back to the sources of the benefits. This would seem to be sound economics and sound public policy.

Can Costs Be Interesting?

WHEELER MCMILLEN, one of our well-known members in the ASAE, has something of special interest to extension agricultural engineers in his signed column of comment appearing in this month's issue of "Farm Journal." He quotes an extension man as saying:

"If I talk about prices, farmers will sit on the edges of their seats for an hour, and then ask questions half the night. If I talk about costs, they want to go home early."

Mr. McMillen draws the conclusion that "better talks on costs had better be made." In this we concur, but we doubt that it is enough. We have long pondered the apparent fact that most farmers are predominantly price-minded, nearly numb when it comes to costs. Some of this is sheer psychology, the same craving for "getting" which inspires letters to Santa Claus. But it also is true that price is a definite, tangible quantity, whereas cost usually is a nebulous composite of many factors, some of them assumptions of dubious accuracy.

Pandering to the price-complex and its political concomitants, too much of cost discussion sets forth to prove that farm costs are high, all as a basis for cultivating discontent and for pressuring in behalf of higher prices. All too seldom do we see a success story built around cost-reduction, with actual figures quoted and specific methods cited. Possibly the professional writers for farm and general reading keep away from costs simply because they know it is psychologically of little allure.

It is more than likely, however, that such writers find a dearth of data for cost-based stories. Our opportunity is not to invade their province, but to cultivate their acquaintance and supply them with "leads." In return they may be able to teach us something about the form in which cost data should be collected and presented in order to be readable and convincing.

Impact of Interest

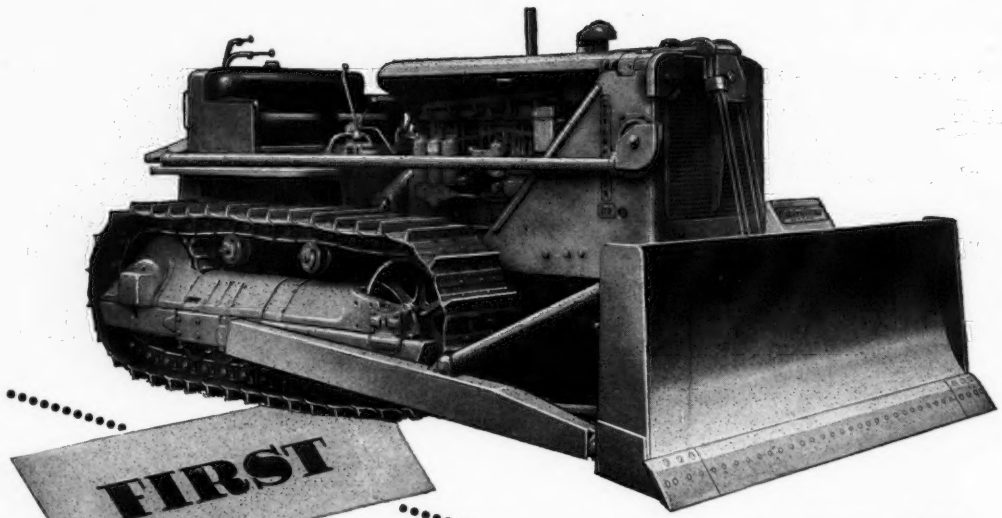
IN OTHER comment on this page we refer to the flood-control component of pond value as being economic only at very low interest rates. It seems in order to add that the general trend toward low interest rates, both public and private, is full of meaning for all agriculture and especially for its engineering aspects. This is all the more true when declining interest goes hand in hand with advancing labor rates.

If the cost of investment capital comes down from six to four per cent, it means that a machine is worth as much at a purchase price of $1500 as it formerly was worth when priced at $1000; provided, however, that the increased price buys a 50 per cent increase in durability so that depreciation comes down pro rata with interest. Since the perishable parts of a machine usually can be made longer-lived at less than proportional increase in the cost of the whole machine, the way is opened for general improvement of all farm machinery.

Because annual depreciation is lower in the case of buildings and other so-called permanent improvements, interest is more the dominating factor and lower interest makes economic a relatively higher investment. It may be well for us to revise all our thinking with respect to interest and investment, particularly as to farm structures.

Thus far we have ignored the relation to labor costs. To the extent that we can regard buildings and machines purely as multipliers of man-capacity, the optimum investment, or its annual charge, increases in proportion to the wage rate. If prevailing postwar farm wages settle at double the prewar rates, much higher investment charges will be economic.

Combining the trends in both interest and wages, it seems logical to look for an era of steady and substantial increase in farm equipment, both structural and mechanical. It should embody advances both in durability and efficiency, since it is not at all certain that farm product prices will keep pace with farm wages, and economies from equipment may have to absorb the difference.



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AGRICULTURAL ENGINEERING

VOL. 27 JANUARY, 1946 NO. 1

Flood-Control Aspects of Farm Ponds

By Austin W. Zingg

MEMBER A.S.A.E.

THE PRELIMINARY postwar planning goal for the State of Missouri calls for one-half million farm ponds. This large number of ponds has focused attention on their possible value as a flood-control measure. No comprehensive study of their worth to flood control has previously been made. It is, therefore, natural that current opinion varies regarding this aspect of ponds.

This study has been confined to the direct physical effects of ponds on floods. Ponds may also be credited with a somewhat broader service to flood control. They are a necessary complement to the production of forage crops, which in themselves alleviate the upstream flood problem. In Missouri the pond construction program is based primarily upon the need for the distribution of a water resource. Their proper placement will permit the utilization of an increased acreage of forage crops by livestock grazing and result in favorable changes in land use. The over-all economic benefits from a conservation program of all farm resources are also sufficiently great to encompass the construction of farm ponds. Many farmers contemplate the building of a pond or water supply in each field or grazing area on the farm. A number of them have already attained this goal.

In addition to providing a supply of water to livestock, ponds have many other recognized uses or values, a few of which are esthetic and recreational, as, for example, fish and wildlife production. Other uses include fire protection, limited irrigation, and supplemental household water supply. Ponds also become an integral part of and facilitate water-disposal or management systems. Where so many worthwhile uses are credited to ponds, the question of their direct value to flood control is not a limiting factor to their application.

The purpose of this study is (1) to evaluate the direct effect of a complex of ponds on floods and (2) to determine whether ponds can be modified to yield additional flood control economically.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is based on a cooperative research study by the Missouri Agricultural Experiment Station and the office of research, Soil Conservation Service, U. S. Department of Agriculture.

AUSTIN W. ZINGG is associate soil conservationist, Soil Conservation Service, U.S. Department of Agriculture.

AUTHOR'S NOTE: Acknowledgment is gratefully made to H. L. Cook, hydraulic engineer, War Food Administration, for guidance in developing techniques for the study and for constructive criticism in the preparation of this report; also to D. A. Russ, agricultural aid, for assistance in carrying out the details common to an evaluation of this nature.

Fig. 1 A farm pond near Columbia, Missouri. The general farm and conservation utility of good ponds like this is great. (University of Missouri photo)

The study on which this brief summary report is based was initiated in 1944 as a contribution by the Research Division of the Soil Conservation Service to the "Cooperative Investigation of the Meramec River Basin, Missouri" (An investigation made by 14 federal and state agencies voluntarily cooperating in the planning of a comprehensive program for the development of the natural resources of the Meramec River Basin). The findings are based upon the floods and flood damages which have occurred on the 3,939-square mile area of the Meramec Watershed. They are not directly applicable to other watersheds or hydrologic regions. The Meramec Watershed is located in East Central Missouri in the humid climatic region. It experiences an annual rainfall of 42 in. This amount of rainfall equals the estimated annual evaporation from shallow-water surfaces.

In presenting the findings of this study the details of methodology will be minimized. In so far as possible it will be confined to a discussion of the results.

Two kinds of ponds were evaluated, namely, (a) the "ordinary" stock water pond provided with a side spillway around one end of the earth dam and (b) a "retarding" type pond provided with both a side spillway and a small drawdown pipe. The drawdown pipe was designed to discharge the flood runoff temporarily stored above its inlet and below the bottom of the side spillway.

For purposes of calculating the effect of "ordinary" stock ponds on floods, it was assumed that all ponds would be alike. They would also have the following characteristics:

1 Contributing watershed, 8 acres

2 Pond area gradually increasing with depth to ½ acre at the spillway level

3 Capacity of pond at spillway level, 2.3 acre-feet

4 Sodded spillway channel 20 ft wide at bottom

5 Bottom of spillway 10 ft above bottom of pond.

In evaluating the effect of "retarding" ponds calculations were made for four different volumes of temporary storage; that is, separate evaluations were made for ponds capable of detaining 0.4, 0.9, 1.4, and 2.4 in of runoff from the contributing area. These temporary storage capacities were in addition to the capacity of the pond at the entrance to the drawdown pipe. The other characteristics of the "retarding" pond were held constant and were as follows:

1 Contributing watershed, 8 acres

2 Pond area gradually increasing with depth to ½ acre at the elevation of the inlet to the drawdown pipe

3 Capacity of pond at pipe inlet level, 2.3 acre-feet

4 Steel drawdown pipe 2

in in diameter installed so that the maximum rate of outflow equals 10 cfs per square mile of drainage area (equivalent to 1/3-in runoff per 24-hr day)

5 Inlet to drawdown pipe 10 ft above bottom of pond

6 Sodded spillway channel identical with that used for the ordinary pond with bottom placed at elevations approximately 0.5, 1.3, 1.8, and 3.0 ft above the inlet to the drawdown pipe. This would provide temporary storage capacities for 0.4, 0.9, 1.4, and 2.4 in of runoff from the contributing watershed.

In calculating the effect of the "ordinary" stock pond on floods two factors were taken into account:

1 The amount of water that would be permanently retained in the pond between the existing water level and the spillway level at the time of rainfall and runoff. This may be called the "abstraction" from floods

2 The temporary storage effect that comes into play when a flood raises the surface of the pond above spillway level. This is ordinarily called the "spillway storage effect."

A third factor enters into the evaluation of "retarding" ponds:

3 The volume of water temporarily detained in the storage space existing between the elevation of the inlet to the drawdown pipe and the side spillway level and discharging through the pipe at a relatively low rate.

Abstraction of Flood Runoff. The first problem considered with respect to ponds has to do with the amounts of runoff they will permanently retain or abstract from floods. The storage space available in the pond at a given time depends upon:

1 The subtractions from storage by evaporation, seepage, and use since the time of last filling

2 The additions to storage by rainfall and runoff (either surface or subsurface) since the time of last filling.

The volume of storage space available at the time of a flood is fortuitous. Records for a period of years must, therefore, be used to evaluate a system of ponds. The procedure is in the nature of a "bookkeeping" task. To form an estimate of the abstraction ponds will yield under assumed use conditions, a 16-year evaluation series of hydrologic data, 1927-43, was used. Amounts and time of precipitation from U. S. Weather Bureau gages on the Bourbeuse River Watershed, an 848 square mile tributary of the Meramec River, were utilized for this purpose. U. S. Geological Survey stream gagings at Union, Missouri, on the Bourbeuse River gave records of the runoff experienced throughout the period. Average elevation losses from the water surface of ponds were estimated by months and days as follows:

Mo.	Evaporatoon in/day	Livestock use, in/day	Seepage, in/day	Total, in/day	Total, in/mo
Jan	0.01	0.01	0.02	0.04	1.24
Feb	.02	.01	.02	.05	1.40
Mar	.06	.01	.03	.10	3.10
Apr	.12	.01	.03	.16	4.80
May	.16	.02	.05	.23	7.13
Jun	.21	.02	.05	.28	8.40
Jul	.22	.02	.05	.29	8.99
Aug	.22	.02	.05	.29	8.99
Sep	.18	.01	.03	.22	6.60
Oct	.12	.01	.03	.16	4.96
Nov	.06	.01	.02	.09	2.70
Dec	.02	.01	.02	.05	1.55
Annual total (inches from surface of pond)					59.86

Losses for a specific time would vary appreciably from these values. This treatise is not, however, a critical study of pond supply; thus average values are considered adequate to illustrate the performance of a pond during flood periods.

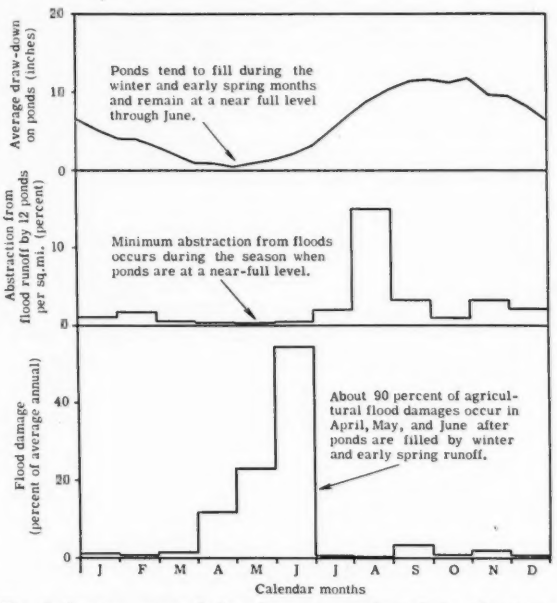
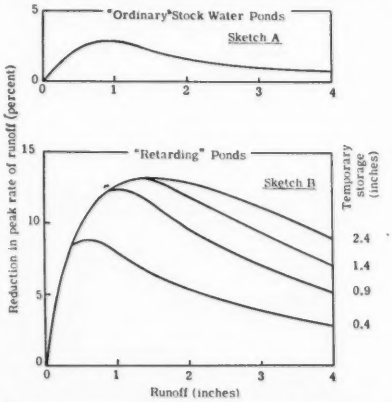

Average draw-down on ponds (inches)
Ponds tend to fill during the winter and early spring months and remain at a near full level through June.
Abstraction from flood runoff by 12 ponds per sq.mi. (percent)
Minimum abstraction from floods occurs during the season when ponds are at a near-full level.
Flood damage (percent of average annual)
About 90 percent of agricultural flood damages occur in April, May, and June after ponds are filled by winter and early spring runoff.
J F M A M J J A S O N D
Calendar months

Fig. 2 Average seasonal drawdown on ponds and the abstraction they will effect on flood runoff in relation to the time of occurrence of agricultural damages on the Bourbeuse watershed

After deleting base stream flow from the gagings made at Union, the recorded runoff, precipitation, and estimated pond losses were projected to 12 ponds per section on the drainage area of the Bourbeuse River. The results of the study are summarized graphically in Fig. 2, wherein the calculated average drawdown of the ponds in surface inches is plotted by calendar months.

The average maximum drawdown of the pond surface is somewhat more than one foot in September and October. The ponds then fill during the winter period, and less than 1-in drawdown is present by the first of April. The per cent abstraction which the ponds would, on the average, effect on storm runoff of sufficient magnitude to cause flood damage is plotted by months on the same figure. It will be noted that less than one per cent abstraction of runoff is occasioned by the ponds during April, May, and June, when the average drawdown is at a minimum. Larger abstractions have occurred during the latter half of the year,



Drainage area Sq.Mi.	Correction factor
75	1.00
150	.98
300	.95
500	.89
750	.83
1,000	.78
1,500	.70
2,000	.65
2,500	.61
3,000	.58
3,500	.56
4,000	.53

The curves shown are applicable to areas of less than 75 square miles. The above correction factors must be used to adjust these curves to represent reductions on larger land areas.

Fig. 3 Curves showing average storm-runoff rate reductions by 12 ordinary stock water ponds per section, and by 12 retarding ponds per section where capacity for varying amounts of storage is provided above the entrance to the drawdown pipe

the peak month being August. These averages are based on a total of 41 damage-producing storm-runoff periods. Of this total number of floods, ponds were credited with abstracting runoff from 76. Slight increases in total runoff were estimated for 56 floods, and 9 were not affected. The average net abstraction for the floods of each month is, however, positive.

The per cent of average annual agricultural flood damage occurring in each calendar month is also plotted in Fig. 2. It is readily seen that the months of April, May, and June are of prime importance and that 90 per cent of the total annual damage has been experienced during this three months' period. The remaining nine months of the year have, on the average, yielded only moderate damage aggregating the remaining 10 per cent.

The fact that minimum abstraction of flood runoff occurs during the period of maximum flood damage limits the flood-control value of ponds. Average abstraction during the months of April, May, and June is 0.3 per cent. During the remaining nine months of the year it averages 2.2 per cent. Weighting these reductions by the per cent of total damage yields the average annual reduction to flood runoff. This value is 0.5 per cent.

The flood-control values of ponds cited above are based wholly on a theoretical consideration of estimates. To check these estimates with actual field performance, a survey of ponds was made during May of 1945. The results of this study were found to be in general agreement with those previously determined for the Bourbeuse Watershed and are contained in Appendix A.

Spillway Storage. Even though a pond may be full to the spillway level at the time of a storm runoff, it will effect a change in the hydrograph of flood inflow by virtue of spillway storage generated within the pond basin. The hydrograph of outflow is dependent upon the storage relationship: outflow = inflow $\pm$ storage. The effect of spillway storage on the typical hydrograph of flood runoff is to broaden its time base and to reduce and delay its peak rate. In evaluating this feature of ponds the assumption was made that the basin was full to the spillway level at the time of storm runoff. Simplified hydrographs of inflow for varying amounts of runoff were then routed through the pond basin and spillway to determine the hydrograph of outflow.

Hydrographs were subsequently developed for a one-square-mile area both without and with 12 ponds. The hydrographs for a one-square-mile area were then projected to a 50-square-mile watershed and, finally, to the entire area of the Bourbeuse River by flood combination and flood-routing procedures. The details of methodology used for hydrograph development, flow combination, and flood routings through valley storage are contained in a contemporaneous evaluation of larger reservoirs by the author[1].

The flood reductions determined for spillway storage vary with the type and amount of storm runoff. The magnitude of a reduction initiated on tributary areas of approximately 75 square miles was also found to decrease progressively when routed to the drainage network of larger land areas. The reductions determined for tributary areas of less than 75 square miles for varying amounts of runoff of average characteristics are shown in sketch A of Fig. 3. A study of this graph shows that the amount of the flood reduction is approximately 2.5 per cent of a one-inch runoff and decreases to less than one per cent for a 4-in runoff. The tabular material to the right of the graph gives correction factors for projecting quantities read from the curve to points draining larger land areas.

Reductions in the individual floods of the 16-year evaluation series were determined for points throughout the Meramec Basin by the use of the graph and correction factors of Fig. 3. From this study it was found that the average flood reduction by pond spillway storage was approximately 2 per cent on tributary areas of less than 75 square miles. It decreased progressively to approximately 1 per cent on the lower main stem of the 3,939-square-mile basin. The hydrographs of a 1-in runoff on the Bourbeuse River without and with 12 ponds per square mile are shown in the graph of Fig. 4.

No reduction in flood peaks on the main stem could be gained from spillway storage by placing ponds in the lower 25 per cent of the basin. The explanation of this is simple. Runoff from the lower portion of the basin moves out of the main channel ahead of the flood peak, which is normally formed in the upper portion of the basin. In the normal course of events runoff from the lower regions does not contribute appreciably to this peak.

Retarding Ponds. Providing storage space for a portion of storm runoff above the normal full level of a pond and depleting it at a low rate will greatly enhance the flood-reducing effects of ponds. Over and above its value to flood control, the device will yield protection to vegetated side spillways. Many installations have been made for this express purpose. The survey of ponds showed that 40 per cent of them should have spillway repair. This fact attests to the need for supplemental protection. A small pipe to remove prolonged trickles of runoff, in combination with storage to lessen the frequency of runoff, will also permit the successful operation of ponds on areas larger than those normally used. Experience has shown that a drainage area of 12 acres approximates the upper limit on which a vegetated spillway can be maintained without this protection.

The average reductions in floods for varying amounts of storage addition to 12 retarding ponds per section were determined. These values are shown in sketch B of Fig. 3. Storage amounts equivalent to 0.4, 0.9, 1.4, and 2.4 in from the drainage area were used for the purpose of ascertaining the amount which would yield the maximum benefit-cost ratio. Following the general procedures cited previously, the reduced floods during the 16-year period were determined for each storage capacity.

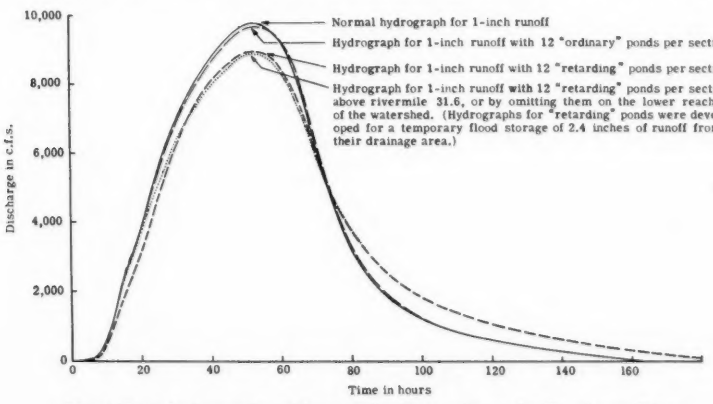

Normal hydrograph for 1-inch runoff
Hydrograph for 1-inch runoff with 12 "ordinary" ponds per section
Hydrograph for 1-inch runoff with 12 "retarding" ponds per section
Hydrograph for 1-inch runoff with 12 "retarding" ponds per section above rivermile 31.6, or by omitting them on the lower reaches of the watershed. (Hydrographs for "retarding" ponds were developed for a temporary flood storage of 2.4 inches of runoff from their drainage area.)
Discharge in c.f.s.
10,000
8,000
6,000
4,000
2,000
0
0
20
40
60
80
100
120
140
160
Time in hours

Fig. 4 Unit hydrographs without and with ponds on the Bourbeuse River

[1] "An Evaluation of Small Upland Reservoirs for Flood-Control Purposes", a study made for the Missouri State Department of Resources and Development and the Missouri Conservation Commission.

As with ordinary ponds, the placement of retarding ponds in the lower one-fourth of the Meramec Basin was not an aid to reducing floods on the main stream. In fact, the retardation of flow in this portion of the basin for two to five days caused its direct addition to the flood peak. Hydrographs on the Bourbeuse River without and with retarding ponds on the lower portion of the watershed are shown in Fig. 4. It is seen that the peak runoff is slightly greater where retarding devices are placed on this portion of the basin than where they are omitted. This illustrates a fundamental principle of flood control which is not generally recognized, i.e., *changing the timing of runoff may either decrease or increase a flood peak.* For maximum flood reduction on a given watershed as a whole, it is often advisable to retard the flow from selected parts of the watershed. The flow of runoff from other portions of the basin may be left unchanged; it may even be expedited by channel improvements to decrease a flood peak at a downstream point. All data relative to flood reduction by retarding ponds were, therefore, determined on the basis of placing them on the upper three-fourths of the Meramec Watershed.

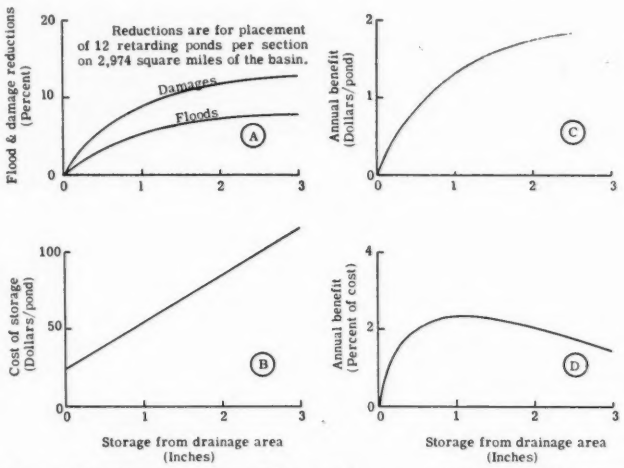


Fig. 5 Data relating to average flood and damage reductions and their cost for varying quantities of storage provided in retarding ponds on the upper three-fourths of the Meramec Basin

The results of this study are summarized by the graphs of Fig. 5. The average flood reduction for 0.5 in of storage addition to 12 retarding ponds per section is read to be 3.5 per cent. For a storage of 3 in a comparable reduction would be 8 per cent, as read from sketch A. These reductions are for the storage additions alone and are in excess of those determined for side spillways.

Economic Evaluation. The relationship of pond cost to the value of the decrease they will make in flood damages will provide a basis for estimating their economic worth for flood-abatement purposes. The two questions to be answered are: first, how much of the cost of construction of an "ordinary" farm pond can be directly justified for flood control purposes, and second, can the addition of retarding features to a pond be justified by the decrease it will make in flood damages?

Existing annual flood damages on the Meramec Basin average approximately one-half million dollars. To estimate the value of ponds in reducing these damages the reduced floods and damages with varying numbers and types of ponds per square mile were determined for each of the floods which have occurred during a 16-year period, 1927-43.

The average annual flood-reduction benefit for an "ordinary" pond was found to be 8 cents per year for the portion of runoff permanently retained or abstracted from floods. The reduction in flood peaks associated with side-spillway storage effects accounted for an additional 30 cents annually. Thus, the total value per pond was 38 cents per year.

The normal cost of constructing the "ordinary" pond used in this evaluation was estimated to be $200. At 2.4 per cent interest a benefit of 38 cents per year will capitalize at $15.83. This figure is equal to 8 per cent of the cost of pond construction. Since the ponds evaluated had water-surface areas of one-half acre, the water-surface area at their spillway level has a present worth of approximately $30 per acre for flood-control purposes.

The effects of adding flood-storage features to an "ordinary" pond to form a "retarding" pond were evaluated separately; that is, the flood reductions and economic benefits given are in addition to those determined for an "ordinary" pond. The average flood and damage reductions for varying amounts of storage-capacity addition to 12 ponds per square mile on the upper three-fourths of the Meramec Basin are shown in sketch A of Fig. 5. The annual flood-reduction benefit is also a variable dependent upon the amount of storage space provided. It is shown on an individual pond basis in sketch C of Fig. 5. This benefit increases at a diminishing rate with storage. A maximum of $1.86 per pond per year is credited to a storage space capable of containing 3 in of runoff from the pond drainage area.

The cost of providing storage on a "retarding" pond also varies with the amount provided. The installed cost of a 2-in pipe to deplete the storage was estimated at $25. The cost of the additional earth fill was estimated to be equivalent to $30 per inch of storage for runoff from the drainage area. This variable cost is plotted for various quantities of storage from the drainage area in sketch B of Fig. 5.

The annual benefit in dollars per pond divided by the cost yields the return on the storage investment. When expressed as per cent of the cost, it will vary with the amount of storage addition as shown in sketch D of Fig 5. A maximum annual return equivalent to 2.36 per cent of the cost is shown to occur for a storage slightly greater than one inch from the drainage area; however, the relatively flat shape of the curve near the point of maximum returns shows that the storage capacity can be varied between ¾ and 1.4 in and the returns would be in excess of 2.3 per cent.

Let us consider that a storage capacity for 1.3 in of runoff from the drainage area is the optimum amount to provide on "retarding" ponds on the Meramec Basin. The cost of its construction could then be capitalized to yield direct flood-control benefits equivalent to an interest rate of 2.35 per cent annually. The original cost of this amount of flood storage would be $64. The annual flood-reduction benefit from it would be $1.50 per pond. As read from sketch A of Fig. 5, the average flood reduction for its addition to 12 ponds per square mile on the upper three-fourths of the Meramec Basin would be approximately 6 per cent. The accompanying reduction in average annual flood damage on the basin would be 10 per cent. Storage capacity for 1.3 in of runoff from an 8-acre area is equivalent to 1.15 acre-feet. This would be contained in a vertical storage space of 1.7 ft between the elevation of the drawdown pipe and the bottom of a side spillway. The present worth of the storage would be equivalent to $54.20 per acre-foot where the interest rate is 2.4 per cent annually.

Summary and Interpretation of Results. All quantities

of flood and damage reductions given for ponds are based on many estimates and heretofore unused procedures. They should, consequently, be considered as estimates and not as precise values.

Twelve "ordinary" farm ponds per section on the Meramec Basin were, on the average, estimated to reduce damage-producing floods by 2 per cent. This was through their ability to abstract runoff and to reduce flood peaks by side-spillway storage effects. The accompanying average reduction in flood damages was equivalent to 38 cents per pond annually. The capitalization of this annual benefit at an interest rate of 2.4 per cent would merit the expenditure of $15.83 per pond; thus approximately 8 per cent of its construction cost of $200 can be directly justified for flood-control purposes.

Twelve "retarding" farm ponds per section on the upper three-fourths of the Meramec Basin were estimated to make an over-all average reduction in floods of 8 per cent. This was where they contained storage capacity for 1.3 in of runoff from their drainage area between the inlet to a drawdown pipe and the bottom of the side spillway. The accompanying average reduction in flood damages was equivalent to $1.88 per retarding pond annually. Of this annual benefit 38 cents is credited to abstraction and to the effects of side-spillway storage. The remainder of $1.50 is attributed directly to the retarding features added to the pond. The annual benefit of $1.50 per pond will capitalize the cost of adding retarding features at an interest rate of 2.35 per cent.

The flood reductions and benefits ascribed to ponds on the Meramec Basin would not necessarily be applicable to other drainage basins in the Midwest agricultural area. Cook[2] reports that the annual flood damage in headwaters tributary areas in humid agricultural regions averages about $100 per square mile. A comparable figure for the Meramec Basin is approximately $50 per square mile. The physical reduction of floods by ponds placed on other drainage basins in the humid agricultural regions would perhaps not be substantially different from those calculated for the Meramec Basin. It is, however, reasonable to assume that the accompanying benefits would normally be of a somewhat higher order.

Definite limitations would be common to the control of floods with "retarding" ponds. First, the storage which it would be economical to provide in them is limited. Where 1.3 in of storage were allocated to flood-control purposes, most of the benefit came from their effect on relatively small but frequent floods. On the upstream portions of the Meramec Basin small floods containing less than 2 in of runoff account for about 60 per cent of the average annual damage. Second, twelve ponds per section having drainage areas of 8 acres can, at most, modify runoff from 15 per cent of the land area. This second limiting factor could be improved by building larger ponds with proportionally larger drainage areas, although other economic values in addition to flood benefits would necessarily be a prerequisite to this step.

The probable effect of farm ponds on the floods of larger rivers should be discussed. Many of the factors governing the control of floods on the Meramec Basin have an analogy on a larger river system. Abstractions of flood runoff made in the headwaters of small streams would result in abstractions on larger rivers. The runoff which results in a flood on small streams will, however, not necessarily produce a flood on a larger river. Whereas some nine floods produce some damage annually on the Meramec Basin, less than one flood per year is common to the main stem of the Missouri River. These relatively infrequent floods on the Missouri River usually come in the spring months of April, May, and June, a time when large land areas have lost their capacity to retain precipitation. The abstraction ponds would make on these floods would be small. It would be reasonable to expect less than the 0.3 per cent estimated for floods on the Meramec Basin during these months.

The modifications made by side-spillway storage and retarding features on ponds on the headwaters of small streams were shown to lose approximately one-half of their effectiveness when routed to the main stem of the Meramec Basin. Upon projection to a drainage area over 100 times as large, these relatively small changes in the regimen of runoff would become negligible.

It is apparent that the role of farm ponds in flood control will be to afford auxiliary protection from small floods common to headwaters drainage areas. The direct flood-reduction benefits will not be commensurate with the total cost of pond construction; however, the cost of adding retarding features to ponds can be justified on small basins having relatively high flood damages.

[2] Cook, H. L. "Flood Abatement by Headwaters Measures." Civil Engineering, pp. 127-130, March, 1945.

APPENDIX A

A state-wide survey of ponds in Missouri was carried out by the Missouri Agricultural Extension Service in May, 1945. Precipitation in the spring of 1945 was above normal over most of the state and resulted in widespread flood damage. Data relative to the pond area, contributing drainage area, soil type, existing drawdown, visible leaks through earth fills, etc., were secured on 268 ponds in 40 counties. A summary of information from these data is as follows:

Average surface area of ponds (acres)	0.43
Average contributing pond drainage area (acres)	7.00
Ponds full to spillway level (number)	200
Full ponds discharging a trickle of water through spillways (number)	147
Side spillways needing repair (number)	111
Visible leaks through earth fills (number)	80

Thus, of the total number of ponds, 75 per cent were full to the spillway level, and 55 per cent were discharging a small continuous trickle of water through their spillways. Forty per cent of the spillways were also in need of repair. Visible leaks through earth fills were observed on 30 per cent of the ponds, and 25 per cent of the ponds were not full to the spillway level. Sixty-eight ponds which were not full contained storage space for 27 acre-feet of water, which was equivalent to 2.8 in drawdown over the surface of all 268 ponds. This average figure of pond drawdown does not fairly represent the capacity of the ponds to hold runoff from a storm. Slightly more than one-half of the available storage was contained in only 10 ponds. It would, therefore, not be fully utilized by a storm runoff of ordinary proportions. Five ponds were reported to have drawdowns in excess of 3 ft. In all probability this means they were newly constructed ponds which had not filled, or that they leak at excessive rates.

The average storm causing flood runoff during the month of May on the Bourbeuse Watershed has contained 1.90 in of precipitation and yielded 1.00 in of runoff. By considering all 268 ponds as a complex applied to the Bourbeuse Watershed at the rate of 12 ponds per section, it was found that their capacity to abstract runoff would reduce an average May flood by 0.67 per cent.

Fertilizer for Tung Trees

Paying $2.50 an acre for fertilizer that would not increase the yield of the trees in a tung orchard proved good business for the grower as measured by results reported by the United States Department of Agriculture.

The expenditure of $2.50 an acre was for a low-cost phosphate fertilizer. Earlier tests in the orchard showed no gain in yield from phosphate fertilizer. The soil had enough phosphate to meet the light needs of the tung trees. The soil, however, did not have enough phosphate to supply the heavier demands of a cover crop of winter legumes. The tung orchard did need nitrogen fertilizer, and by supplying phosphate the grower encouraged a good cover crop. This drew from the air nitrogen that would have cost up to $10 an acre in the cheapest commercial form.—THE CHEMURGIC DIGEST.

The Mechanical Features of Farm Dehydrators

By Ben D. Moses
FELLOW A.S.A.E.

THE field of dehydration has become very broad; it covers a wide variety of products and involves many details. This paper, however, will be confined to experiences with three California crops —prunes, walnuts, and rice.

Prunes are a heavy fruit, having 65 to 70 per cent water when fresh and 20 per cent when dry. They are dehydrated at air temperatures as high as 175 F (degrees Fahrenheit) generally in dehydrators that use air recirculation.

Walnuts are sensitive to high temperatures, 110F being the maximum recommended. They have as much as 35 per cent water when fresh, but only 7 to 8 per cent when dry. Air recirculation may be used during the first stages of drying, but often is not used at all.

This is a walnut dehydrator. The sacked fresh nuts are received at the left, elevated to the huller, flow by gravity through the washer, then to the assorting tables. They are then elevated into bins, where they are held until loaded into the dehydrator in the center of the building. Finally they are sacked and hauled by truck to the packing house. In 1944 this plant delivered 365 dry tons of English walnuts to the packing house

Although rice may have as much as 30 per cent water when harvested, the amount generally does not exceed 22 or 23 per cent. The crop is dried to about 15 per cent at a rice temperature lower than 110 F, usually without air recirculation.

In general principles, farm dehydrators do not differ from commercial plants; they both use heating chambers, air ducts, fruit compartments, air heaters, blowers, and controls, differing mainly in size. The farm plant is adapted to a shorter period of operation than a commercial or cooperative plant and is generally less flexible. In either case, dehydration is effected by evaporation of water from the fruit surface, air being used both as the medium of heat transfer and as the vehicle for removing the water vapor.

This water removal is governed by four fundamental laws, as follows:

1 Evaporation cannot exceed the rate of water movement from the inside of the material to the exposed surface.

2 Evaporation cannot exceed the absorptive capacity of the air passing over the fruit or through the fruit mass.

3 The amount of heat that enters the drying chamber is the same as that which leaves, plus any losses due to leaks or radiation.

4 The mass of material (including of course the fruit, the air, and the equipment) which enters a dehydrator is equal to that which leaves.

These fundamentals point to the possibility of setting up heat and mass balance equations.

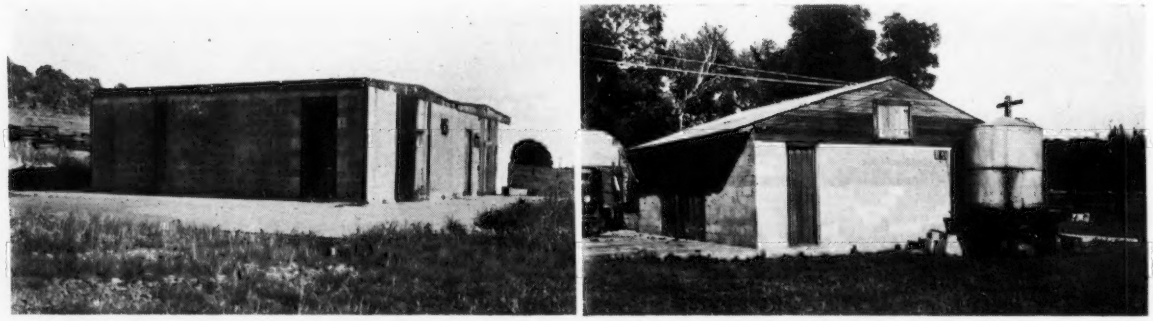
Ordinary heat physics can be applied to the analysis of the drying air, and psychrometric tables and charts have been arranged that simplify the work. The rate at which heat penetrates inward and at which water moves outward during the drying process is less well known. Experiments conducted on some commodities have shown, however, for different conditions of pretreatment, air temperature, humidity, and velocity, the drying rates that make it possible to predict the heat and air requirements for best results.

From the curves obtained by drying many samples of French prunes under controlled conditions and from observations at operating plants, Rene Guillou was able to derive the following expression:

$$T = \frac{1}{K} \log \frac{W_1}{W_2}$$

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Davis, Calif., January, 1945.

BEN D. MOSES is associate professor of agricultural engineering and agricultural engineer in the agricultural experiment station, University of California.



Left: A double or twin-unit farm fruit dehydrator for drying prunes. Each unit has a capacity of 4 tons of fresh fruit or 1.6 tons of dried prunes per day • *Right:* A 6-ton prune dehydrator built of Basalite hollow blocks and galvanized iron roof. Diesel oil direct firing is used for heat

where $K = 0.2 \left[\frac{t}{165}\right]^4 \left[\frac{V}{600}\right]^{0.2} \left[\frac{100\text{-}H}{60}\right]$

t = air temperature in degrees Fahrenheit
V = air velocity in feet per minute
H = relative humidity in per cent
W_1 = free moisture (per cent of dry matter) at the start
W_2 = free moisture (per cent of dry matter) at the end.

(For detailed discussion see AGRICULTURAL ENGINEERING, October, 1942, vol. 23, no. 10.)

This expression assumes a constant dry-bulb temperature, requires modification where the temperature drops along the tunnel, but illustrates nicely what can be done when sufficient experimental data are at hand.

Certain facts about dehydration are of material assistance in design. Some may seem self-evident and perhaps trite, but all are important to keep in mind.

1 *Drying is fastest when the fruit is wettest,* a fact well illustrated in the accompanying dry-away curves (Fig. 1). In curve A, when prunes were dried under constant-temperature, about 55 per cent of the water that was evaporated in 24 hr came off in 4 hr, or one-sixth the time, while 75 per cent came off in 8 hr, or one-third the time. Curve B shows a condition simulating that existing in a counter-flow tunnel where the fresh fruit enters the cold end and the dry fruit leaves at the hot. Even under these conditions 36 per cent of the water came off in one-third the time, while 62 per cent was off in one-half the time. Similar experiments with rice, which contains only about 20 per cent water, show that over 75 per cent is removed in one-quarter the time and nearly 90 per cent in one-half the time.

These curves bear out the argument in favor of having the coldest, wettest fruit contacted by the coldest, wettest air and the hottest, driest fruit by the hottest, driest air, as takes place in counter-flow tunnels or stacks. While this argument generally applies to heavy, fleshy fruit, it does not necessarily hold for leafy vegetables or for material that has been shredded, sliced, or diced.

2 *The hotter the air, the more moisture it will hold;* 90-deg air will hold 220 grains (0.031 lb) of water per pound of dry air when saturated, while 165-deg air will hold 2,500 grains (.355 lb) of water per pound, over ten times as much.

3 *The wet-bulb temperature of the air after it leaves the heater until it leaves the fruit is practically constant,* unless heat is added or lost by radiation or leakage on the way. The relative humidity therefore builds up at the expense of the dry-bulb temperature.

The values shown in the accompanying table, picked from a psychrometric chart, illustrate this point. This table shows 0.00026 lb of water absorption capacity per pound of dry air per degree rise in temperature.

Table Showing Relation between Dry-Bulb Temperature, Relative Humidity, and Moisture Content of Air Held at a Constant Wet-Bulb of 120 F

Dry bulb, deg F	Relative humidity, per cent	Pounds of water per pound of dry air
200	12	0.0600
190	14	0.0626
180	18	0.0652
170	25	0.0678
160	32	0.0704
150	42	0.0730
140	55	0.0756
130	75	0.0782
120	100	0 0808

Van Arsdel in an article in "Food Industries" for October, 1942, gives 0.001 lb of water vapor for each 5-deg rise in temperature. For practical purposes of estimating, 80,000 cu ft per lb of water per degree rise is a commonly used constant.

4 *High dry-bulb and wet-bulb temperatures tend to produce case hardening,* bleeding, or cracking in prunes, or checking in rice, whereas low dry-bulb and high wet-bulb retard drying and may affect quality.

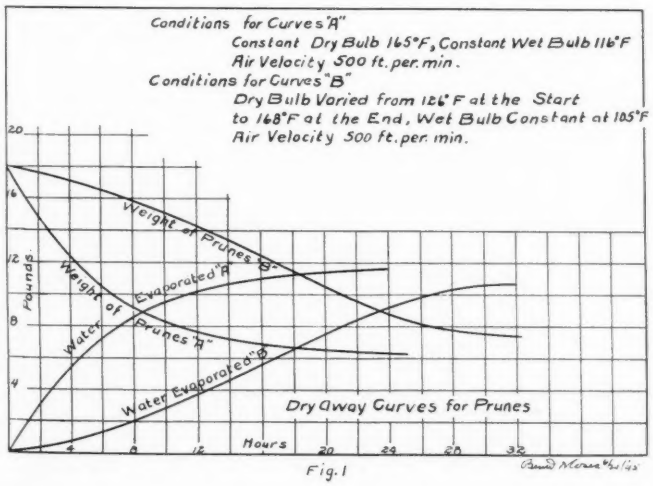
5 *A relative humidity of 25 to 30 per cent for the hot air is recommended* for prunes and most other fruits.

6 *Wet-bulb temperature control is important* where the dry-bulb temperature is high, above 110F, and where air recirculation is employed.

7 *Uniform air velocity and temperature distribution are* essential to uniform drying.

8 *Air velocity is usually defined* as the cubic feet per minute per square foot of cross-sectional area of the tunnel or fruit space.

9 *Friction loss through the fruit space varies* approximately as the square of the air velocity.


Conditions for Curves "A"
Constant Dry Bulb 165°F, Constant Wet Bulb 116°F
Air Velocity 500 ft. per. min.
Conditions for Curves "B"
Dry Bulb Varied from 126°F at the Start
to 168°F at the End, Wet Bulb Constant at 105°F
Air Velocity 500 ft. per. min.
Weight of Prunes "B"
Weight of Water Evaporated "A"
Weight of Prunes "A"
Water Evaporated "B"
Pounds
Hours
Dry Away Curves for Prunes
Fig. 1

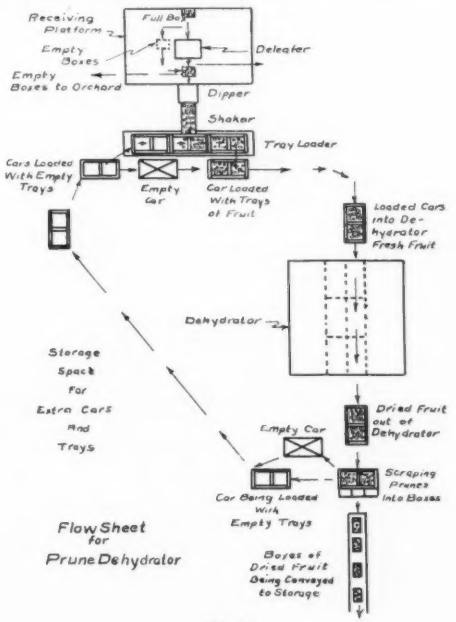


Fig. 2

10 Some practical values for the friction drop follow: (a) *For French prunes* on trays stacked 2⅞-in centers: 0.025 in of water per foot of air travel at 600 cfm per sq ft of area. (b) *For walnuts* in bins: 0.2 in per ft of depth at 125 cfm. (c) *For rice* in bins or sacks: 0.375 in per ft of depth per 40 cfm.

11 *Generous plenum or mixing chambers produce the best mixing.* A fan should not be given this whole responsibility. In general, a good fan makes a poor mixer, and a good mixer makes a poor fan.

12 *It is desirable to maintain approximately 15-deg differential* between dry bulb on and off the prunes to prevent "sweating." The figure is somewhat lower for both rice and walnuts. This differential is determined by the drying temperature, the permissible wet-bulb, the depth of the material, and the air velocity.

13 *Reversal of air flow through the material is desirable* in order to obtain uniform drying. This applies particularly to a long air path and to material with high moisture content.

14 *Movement of the material within the dehydrator,* such as takes place in rice driers where the rice flows downward through a column, or in stack-type walnut driers where the nuts are dumped from one bin to another, evens up the drying. This is not practicable, of course, in tray-type dehydrators.

15 *Wall insulation* is not important in drying rice or walnuts because of the low temperature in the dehydrator.

16 *Good insulation* in walls, ceiling, and doors is profitable in prune and most other fruit dehydrators because of the relatively high temperature inside the tunnel.

17 Where double-wall construction is used, *the interior walls should be moisture-tight.* If, however, the outside is of loose construction, any breathing that takes place will be toward the outside, and condensation within the walls will be avoided.

Fan or blower selection must be based upon the air quantity and resulting air pressure, and *should* be such as to simplify air flow and construction. Where there is danger of the pressure falling to a very low value, a "non-overloading" fan should be chosen for protection against motor overloading. Low-pressure fans should be favored because of reduced first cost, and high-speed fans are better for direct drive from an electric motor.

The following laws which hold for centrifugal and radial-flow fans, aid materially in selecting the proper fan or blower or in making adaptations and adjustments:

1 Capacity varies as the $(\text{rpm}) \times (\text{size})^3$

2 Pressure varies as the $(\text{rpm})^2 \times (\text{size})^2$

3 Horsepower varies as the $(\text{rpm})^3 \times (\text{size})^5$

From these laws any relation between size, capacity, pressure, horsepower, and speed can be estimated. For example, solving Nos. 2 and 3 simultaneously gives

4 Horsepower varies as $\dfrac{(\text{pressure})^{5/2}}{(\text{rpm})^2}$.

For any one fan the size is a constant and laws 1, 2, and 3 become:

(a) Capacity (cfm) varies as N

(b) Pressure varies as N^2

(c) Horsepower varies as N^3

Well-made fans are designed to stand tip speeds of about 10,000 fpm. Outlet velocities vary up to 5,500 fpm.

The total heat required involves that used for warming up the fruit, trays, cars, and building, and for evaporating the water; and that lost through the building, discharged in the exhaust, and recirculated with returned air. The determination becomes too involved to be included here.

If gas or electricity is used, a direct-heating system in which the products of combustion pass through the fruit is practical. When oil is burned it can be used directly for such products as prunes or rice; but where there is danger of producing off-flavors or of discoloration, the products of combustion cannot be passed through the fruit.

In low-temperature drying, as with walnuts and rice, for example, no furnace is required; but care must be exercised to place the burners in such a way as to get uniform heating and mixing of the air.

If oil is used either directly or indirectly, the furnace must be designed to maintain a high enough temperature to volatilize the oil properly, with no hot surfaces to produce "clinkering." Formation of clinkers indicates that some of the oil is "cracking"; the "bridge walls," "fireback," "target," "grill," or whatever is used is too hot, too close to the burner, or perhaps even unnecessary. A long firebox with high-temperature walls should radiate enough heat to volatilize the fuel without any kind of fire wall. Furnace temperatures of 1500 to 2000F should give good results, and the furnace should be lined with firebrick that will stand 2500F. From 1.5 to 2.5 cu ft of combustion volume should be allowed per gallon of oil burned per hour.

For direct heating the entire furnace is placed in the heating chamber in such a manner that both the new air and some of the recirculated air wipe over the walls and roof of the firebox. Because hot furnace gases then mix with this air down-stream from the furnace, furnace insulation other than that provided by the brick is undesirable.

One dehydrator builder very appropriately put it this way: "What we want is precisely what the steam-boiler fireman does not want, namely, high stack temperature and low furnace temperature."

For indirect heating, 2 to 2.5 sq ft of heating or radiating surface should be provided for heating the air for each 10,000 Btu burned per hour, and 0.75 to 1 cu ft of combustion volume.

Automatic control of the temperature of the air leaving the plenum chamber is essential. The simpler it is, the better; but it should be positive and dependable. A dry-bulb thermometer should be in view in the hot-air stream at all times as a check on the thermostat, and a wet-bulb as a check on the recirculation adjustment.

The location and operation of dampers, ventilators, inlet and exhaust openings, and static doors depend on the design of the dehydrator; no one rule will hold for them all. In general, the exhaust opening should be so located as to discharge the air at its coldest, wettest point; should not discharge the air so that it can re-enter the dehydrator; and should depend not upon convection alone but upon the velocity of the air itself, to carry it out of the dehydrator.

Normally, generous openings should be provided for incoming new air, and adjustment should be made on the exhaust end only; no more air can get into the dehydrator than gets out. "Static doors" or those located between the cold end of the fruit tunnel and the heating chamber assist in controlling recirculation.

After the type, size, and design of the dehydrator have been chosen and the individual units decided upon, it pays to construct a flow-sheet diagram so that all operations will be properly coordinated. This can be done by first listing each operation, then arranging them all systematically so as to get good coordination, decrease "prune mileage," and save labor and time (Fig. 2).

A dehydrator is like any other mechanical device: its limits follow definite mechanical *(Continued on page 32)*

Research and Agricultural Reconversion

By Arthur W. Turner
FELLOW A.S.A.E.

AMERICAN agriculture emerged from World War II geared to produce 30 to 35 per cent more than before Pearl Harbor—and this at a time of falling farm labor supply and when available supplies of machinery were far below what farmers wanted. We were blessed with favorable weather during the last few years, but most credit for providing ample food for our armed forces, a better diet than ever before for our civilian consumers, and much food for our allies goes to the American farmer. His share in winning the war is striking testimony to his ability. He worked long hours, planned his operations carefully, incorporated agricultural technological developments, managed well, and gave to us and to our allies a phenomenal supply of food. This record indicates in no uncertain terms that we have had a veritable production revolution.

This revolution is not reversible. We neither want to nor can go back to prewar days. Yet agriculture has its reconversion problem. Wartime production levels in agriculture will tend to persist regardless of economic conditions. Total farm production is responsive to increased prices or income. But, once expanded, it is not quickly responsive to low prices or depressed conditions. Moreover, there is every reason to believe that improved farm technology as a result of agricultural research will increase at a rapid rate. Improved varieties of plants and livestock will be grown on more farms; more and better fertilizers will be used; better feeding and breeding practices will result in greater production of livestock, dairy and poultry products per pound of feed consumed. All of these will tend to increase the production per acre.

Concurrent with these advances farmers will continue to replace animal power with tractor-operated machines developed for special crops and small farm needs. With one type of technological advance reducing acreage requirements and another reducing labor requirements, it is obvious that the total output of all farm products will be extremely difficult to hold down in future years even if such a procedure might seem advisable.

Peacetime requirements can and will be different than prewar needs. Take, for example, one crop—sometimes called the "miracle crop"—soybeans. Production increased from 77½ million bushels in 1940 to about 200 million bushels this present year, or close to 200 per cent increase. Increased industrial as well as food uses of many soybean products have become so firmly established that a postwar level of production will not be the same as the prewar level. That is only one farm commodity with increasing industrial application. A very important aspect of agricultural research is the development of agricultural substitutes or alternates for expendable non-agricultural resources. When we use coal and petroleum, we are using up natural resources. The development from replaceable agricultural materials of such products as fuel, plastics, and building materials points the way to an economy in the use of our natural resources which will extend greatly their life. That is one way of expanding the farmers' market; however, the largest outlet is continuing the present demand for quantities of quality foods, meats, dairy products, fruits, vegetables. In fact, this latter is the immediate problem while research developments reach commercial production status.

People the world over look to the U. S. Department of Agriculture for leadership in the promotion of successful agriculture, and to the Agricultural Research Administration for the promotion and coordination of agricultural research. Research provides the answer for immediate problems of reconversion as well as the problems of the future. The Agricultural Research Administration is composed of six research Bureaus, the Office of Experiment Stations, and the Agricultural Research Center. The research findings are most interesting. For instance, fertilizer experiments in North Carolina last year gave remarkable increases in the yield of corn by heavier than usual applications of nitrogen fertilizers. State and federal investigators believe that the average yields of corn for the state can be doubled in the next 10 years by more liberal use of fertilizers, at a cost that would make it good business for the farmers. If similar increases could be obtained in other southeastern states, it would have a profound effect upon livestock production in that region and thus help to promote balanced farming in the Southeast.

Agricultural engineers are interested in DDT and what it will do. It looks very promising as a control for some well-known pests such as the Colorado potato beetle, clothes moths, and some others, while it seems to have no effect on other pests. In some instances it kills the insects and also has a bad effect on the plants themselves. We need more information about its effects on plants, soils, and animals.

The potentialities of penicillin in treating livestock diseases are just beginning to be explored. Advances in the use of penicillin in combating human diseases have been phenomenal, but until much more research is done we can only visualize the great good that may follow the use of this drug in combating animal diseases.

Research developments of any of the USDA Bureaus sound like fairy tales or modern miracles. The research work of the Bureau of Plant Industry, Soils, and Agricultural Engineering is arranged in four major groups: Field crops research; fruit, vegetables, and specialty crops research; soils, fertilizers, and irrigation research, and agricultural engineering research. Briefly, some of the contributions of the Bureau are new facts on the killing of weeds with growth-regulating substances such as 2,4-D, announcement of at least 24 new varieties of crop plants, quick methods of increasing new varieties, important improvements in equipment for producing and harvesting peanuts, ways of handling ammonium nitrate fertilizer, new facts on fertilizer placement expanding use of improved distributors, gains in knowledge of production of vegetable seeds, gains in machine production of sugar beets, new facts on production in the western hemisphere of rubber, manila hemp and cinchona, developments in hydroponics or tank agriculture.

The Bureau's research work in agricultural engineering is carried on by the following four divisions: Farm Structures and Rural Housing, Farm Power and Machinery, Mechanical Processing of Farm Products, and Farm Electrification. Together they comprise the largest organization of professional agricultural engineers in the country. Much of the research conducted is cooperative. For example, in our fertilizer-placement studies we cooperate with other divisions of the Bureau, with state agricultural experiment sta-

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ARTHUR W. TURNER is assistant chief, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

tions, and with the fertilizer and farm equipment industries. The objective of this work is to ascertain, by experimentation, where to place each kind of fertilizer with respect to seed, seed piece, or plant of any particular crop. The proper location may vary depending on such factors as composition of the fertilizer, type and condition of soil, kind of crop, root characteristics, climate, moisture conditions, and so on. Experiments in a number of states over a period of 6 years have indicated an increase in yield, by proper fertilizer placement, of from 2 to 26 per cent, or a weighted average of 9.4 per cent increase. On the basis of the 1944 national potato crop value of $567,480,000, an increase of $53,200,000 to the farmer could be expected if best practices were followed by all growers. While the end point of proper placement is increased yields consistent with maintenance of quality, the agricultural engineer's province is to devise mechanisms and machinery to place the fertilizer at any place desired in the studies. The most advantageous location of the fertilizer is of utmost importance to the farmer, and can be determined by the cooperation of several groups of agricultural specialists—agricultural engineers, soil scientists, agronomists, and fertilizer chemists.

THE TEST OF AGRICULTURAL RESEARCH IS ITS PRACTICAL VALUE TO FARMERS

The test of agricultural research is its practical value to farmers. Will the results increase farm income and raise the standard of rural living? While they play an important part in any research program, unlike many other sciences the findings of agricultural-engineering research usually involve machines or materials that have to go through a process of manufacturing development before the farmer can derive the benefit from them. For that reason I want to emphasize that agricultural-engineering research, whether by state or federal agencies, should be conducted in close cooperation with the various related industries to the end that the results are made available to the farmer as quickly as possible. In reality agricultural engineering serves as a liaison agency between public service research and industry.

Another project in the Bureau's Power and Machinery Division is the Pest and Plant Disease Control Laboratory at Toledo, Ohio. In addition to work on ground machine application of both dust and liquid insecticides in our pest control work, we now have two airplanes equipped with new sprayers and dusters. Applying one gallon or less per acre of concentrated insecticides calls for accurate distributing equipment, both for control of quantity and size of droplets. Therein may lie the best method of the future for controlling the corn borer and other widespread pests.

The Tillage Machinery Laboratory at Auburn, Ala., was so attractive to the Army that they "took over" during the war for flotation studies of military vehicles. It is now in process of being reconverted, after which we will resume our research with closer cooperation with agronomists and soils scientists.

Crop production studies include sugar cane at Houma, La.; peanuts and tung nuts at Auburn, Alabama; sweet potatoes at Ellisville, Miss., and Clemson, S. C.; sugar beets, Ft. Collins, Colo., and Lansing, Mich.; and cooperative work with the Soil Conservation Service relative to farm equipment. I had the opportunity of seeing our work in sweet potato harvesting early in October. Successful harvesting at present includes a new procedure in seedbed preparation, planting and cultivating. That indicates how our work often affects the entire crop-production procedure.

It seems to be generally agreed that we are facing a decade of unprecedented activity in building. Buildings on farms have been neglected since the depression of the early thirties. When incomes permitted expenditures, labor and materials were scarce. Now, however, many farm families have saved substantial sums for remodeling or building new homes, barns, and other necessary farm structures.

Farm structures research is entering its fourth major stage. The first stage was to survey farm practices and report majority preferences. The second stage was to use buildings constructed by farmers or state experiment stations as laboratories for experimental work and as demonstrations. Studies are carried on in connection with the regular farm operations so it is quite common to change the experiment frequently to meet the owner's convenience. The costs of such research are relatively low but unfortunately the results are not always conclusive. More recently our bureau cooperated with the Commodity Credit Corporation, which supplied large quantities of corn in Iowa, wheat in North Dakota and Kansas, grain sorghums in Kansas, and soybeans in Illinois, and also loaned bins for experimental work. Because of the enlarged scale of operation through the loan of CCC facilities, studies could be replicated and carried on under controlled conditions. Large-scale experimental work on potato storage in Colorado and apple storage in Washington have been possible through the facilities of farmers' cooperative associations.

The third stage of farm buildings study is the assembling and coordinating of informed opinions on subjects such as the functional requirements of livestock buildings, crop storage buildings and the farm home. While this method has limited advantages, information based on opinions should be used only until fundamental research data is available.

The fourth, and the basic or fundamental research method, provides laboratories in which all factors can be controlled and varied as desired. Such a project is under construction in cooperation with the Bureau of Animal Industry. It deals with the environmental requirements of poultry, and will be conducted in a small poultry house or calorimeter approximately five feet wide by seven feet long by seven feet high built within another building. This is being constructed at the Agricultural Research Center at Beltsville, Md. By use of rather elaborate equipment we can maintain almost any range of temperature, humidity, air movement and lighting conditions in this chamber. In addition it will be possible to measure the amounts of heat, moisture, and gaseous products that the chickens give off under the different conditions. The house will accommodate six to fifteen chickens and will be provided with feeders, waterers, roosts, and nests, so that the chickens may be kept in the desired environment for several weeks or months.

COOPERATIVE STUDIES ON THE ENVIRONMENTAL REQUIREMENTS OF DAIRY CATTLE AND HOGS

A somewhat similar project on the environmental requirements of dairy cattle and hogs is being planned at the University of Missouri. This will be cooperative with the Bureaus of Animal Industry and Dairy Industry. In addition, cooperative work is contemplated with the University of California, which has a very complete calorimeter suitable for the study of the effects of a warm environment upon farm animals.

Our objective is to help provide individual farmers with storage facilities which will enable them to hold their commodities on the farm safely and sell at their convenience rather than on a flooded market at harvest time. Another objective is animal shelters and equipment for maximum meat and animal production from minimum feeds.

New studies in farm homes are under way in cooperation with the Bureau of Human Nutrition and Home Economics. The locations have not all been selected. Other activities of our Farm Structures *(Continued on page 20)*

Lamps of Tomorrow

By Lawrence C. Porter
FELLOW A.S.A.E.

IN THE past all sunlamps have been of the applicator type, i.e., their life, ultraviolet distribution, and cost have been such that the most practical way to use them has been to take relatively short and intense doses. That has mitigated against their wide use in the home: first, because it is a nuisance to have to take time for treatments; secondly, because the fixtures have been heavy, clumsy, and anything but decorative, and, lastly, because the lamps have been relatively expensive.

It has always been the scientist's dream to mix sufficient ultraviolet with the visible light from lamps used for general lighting to provide the health value of outdoor summer sunlight. At long last it seems as if that dream may soon be realized.

Fluorescent Sunlamps. There has been developed recently a phosphor which can be used in fluorescent type lamps to transform the energy of the mercury arc inside the tube to the middle or health-giving ultraviolet rays as the present phosphors turn this energy into visible light.

That means that long life, relatively inexpensive, and low-wattage, tubular-type sunlamps will be available. These may be used in combination with fluorescent lighting tubes.

That may revolutionize sunlamp practice, doing away with floor-stand treatment-type fixtures and getting a mild dosage of ultraviolet over a period of hours from ceiling-type units instead of short heavy dosages from floor units.

It makes little difference as far as the health value goes whether one takes a short exposure at high intensity or a long exposure at low intensity. If the product of time and intensity is the same, the health value is the same, as that depends upon the total energy absorbed by the body. Furthermore, it makes little or no difference what portions of the body receive that energy. It creates vitamin D which the blood distributes throughout the body; for example, rickets in a baby's left wrist may be cured by irradiating the right wrist, or for that matter the face or the foot.

These new sunlamps will have a further advantage, which will be particularly pleasing to many: they emit a higher percentage than the older types of the longer wave ultraviolet which produces tanning. Therefore, it will be easier to get a tan with the new lamps than was possible with the older units.

These new fluorescent-type sunlamps undoubtedly will be used both in ceiling-type units designed for long mild dosages, and in more powerful floor type units for those who do not spend much time under artificial light or who wish to get a powerful dosage in a short time. They also offer interesting possibilities for irradiating groups of industrial workers, miners, etc., and for use in bath cabinets.

These lamps are not yet available, but when reconversion problems permit, it is expected that they will be made in 20 and 40-w sizes, emitting approximately 45,000 and 100,000 E-vitons, respectively.

Germicidal+ Lamps. The value of sunlamps to the poultryman lies largely in the vitamin D creating property of their ultraviolet radiation, most of which lies between 2800 and 3200 Au (Angstrom units). It has been proven that such radiation can be used as a substitution for cod-liver oil or other vitamin D sources in the food. Chicken feed may be deficient in vitamin D content, or the potency of such content may be low. In such cases sunlamps supplementing the vitamin D feed have proven very effective in promoting rapid growth, increasing egg production, increasing the hatchability of eggs, improving the feathering and coloring, etc. Sunlamps have been used for many years in the poultry industry and their value is widely recognized and accepted.

The value of germicidal lamps lies largely in the germ killing properties of their radiation. Many installations have been made that resulted in marked reduction in mortality and some improvement in the general health of the birds.

These two outstanding advantages—better health with consequent increase in egg production plus reduced mortality—could, of course, be obtained by using both sunlamps and germicidal lamps in the poultry. It is logical to suppose that, if both the health radiation of sunlamps and the germ killing radiation of germicidal lamps could be obtained from one lamp, it would be more convenient and more economical. That is exactly what the "germicidal+" lamp does.

These lamps consist of standard germicidal lamps with the addition to the inside of the tube a thin coating of a new phosphor which converts approximately 25 per cent of the 2537 Au, or germicidal output to health radiation in the range of 2800-3200 Au. The other 75 per cent of the output is germicidal radiation. The germicidal+ lamps are therefore interchangeable with standard germicidal lamps of the same wattage.

While it is true that the health radiation is less from these lamps than from the older RS-4 sunlamps, their life is longer—4000 hr versus 1000 hr; and their wattage is lower—15 and 30 w versus 100 w. The lower cost and lower wattage make it practical to mount them 6 ft above the birds (and they should never be lower than that as the germicidal radiation might cause sore eyes) and burn them 24 hr per day. In fact, they should be burned 24 hr per day to give continuous air disinfection. It was practice to suspend the older RS-4 sunlamps 3 ft above the birds and burn them 1 to 2 hr per day. Their intense output of health radiation built up an ample supply of vitamin D under those conditions and the low mounting 2-hr exposure conserved current and lamp renewals. It is a fact that the effect of health radiation is a product of intensity times time. In other words, a short exposure at high intensity has the same effect as a long exposure at low intensity.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

LAWRENCE C. PORTER is illuminating engineer, Nela Park Engineering Division, General Electric Co.

Fluorescent sunlamps and germicial+ lamps

Hence, the low intensity of health radiation from germicidal+ lamps mounted 6 ft above the birds but burned 24 hr per day provides adequate vitamin D.

With germicidal radiation the greater the volume of air irradiated, the better; hence it is practice in poultry houses to use bare germicidal lamps wherever they can be mounted 6 ft above the birds. At shorter distances the birds must be shielded from direct radiation to guard against sore eyes. On the other hand, health radiation is of no value unless it falls directly on the birds. Hence, if bare germicidal+ lamps are used, some of the health radiation would be wasted. Therefore, it is recommended that wide-spread alzak reflectors be used with germicidal+ lamps to collect and concentrate down onto the birds as much of the health radiation as practical. True, that lessens the volume of air irradiated by the germicidal rays; on the other hand, the air below the reflectors is irradiated by a higher intensity than would be the case with bare tubes, and that tends to offset the decreased volume.

From the foregoing discussion it is evident that germicidal+ lamps are only effective where the radiation falls directly on the birds. There is no advantage in using them in brooders, incubators, hatchers, and for upper and lower-air irradiation with battery brooders where on account of the short distances (less than 6 ft) the birds must be shielded from the direct rays of the lamps. For such conditions it is more economical to use the standard germicidal lanmps.

It is suggested that germicidal+ lamps be installed on the same spacing and mounting heights as recommended for standard germicidal lamps, i.e., one 15-w lamp for each 100 sq ft of floor area, or one 30-w lamp for each 250 sq ft. Where standard bare germicidal lamps are already in use, bare germicidal+ lamps may be substituted in the same equipment. For all new installations, however, equipment having wide-spread alzak reflectors is recommended.

Germicidal+ lamps are now available in limited quantities, a 15-w lamp listing at $5.00 and a 30-w lamp at $7.50.

Caution. Exactly the same precautions to protect the eyes and skin of humans working near the germicidal+ lamps must be used as with the standard germicidal lamps. The germicidal+ lamps are not recommended for human beings, as it is impractical to use direct radiation under most conditions unless the eyes are protected by goggles and the skin by clothing.

Research and Agricultural Reconversion

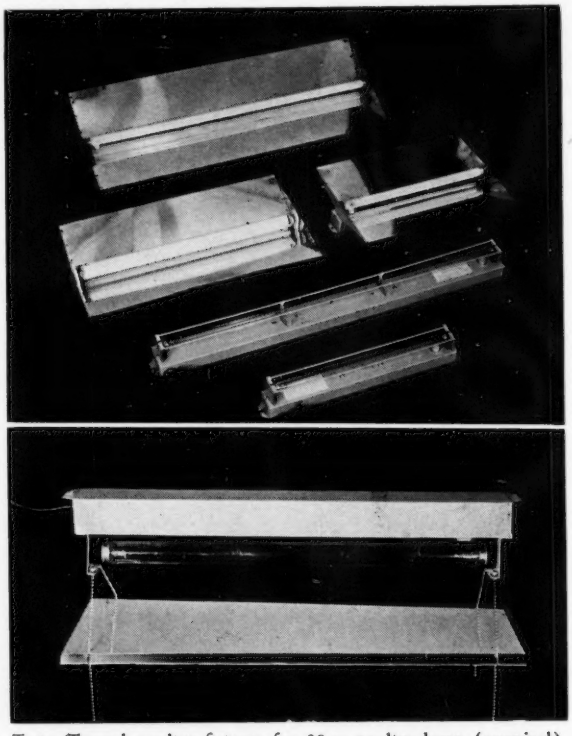
(Continued from page 18)

and Rural Housing Division include studies and uses of new building materials, farm and home utilities and the regional building plan exchange.

Our farm electrification work consists in mow-curing of hay at the Agricultural Research Center and with the Virginia Agricultural Experiment Station at Blacksburg, Va.; flue-curing of tobacco at Raleigh, N. C., and application of refrigeration to farm storages in several locations. The present large investments and anticipated expansion in rural electrification indicate the need for increasing line-building and income-producing uses.

Electricity can play an important part in work simplification in agriculture, and no doubt numerous wartime developments in application of electricity have farm utility which will be revealed through research.

The present Division of Mechanical Processing of Farm Products is expanding into a Rural Farm Industry Division. Our present field stations are the U. S. Cotton Ginning Laboratory at Stoneville, Miss.; Fiber Flax Station at Corvallis, Ore.; and Sansevieria Fiber Station at Boynton, Fla. These are all vegetable fiber activities.



Top: Typical poultry fixtures for 30-w poultry lamp (germisol), 20-w fluorescent sunlamp (not yet commercially available), 15-w poultry lamp (germisol), and 30-w and 15-w germicidal lamps. *Bottom:* A typical poultry fixture for 15-w germicidal lamp for use where mounting height is less than 6 ft above birds

Thus it is that our work can logically expand into rural farm industries. We have inaugurated a project to the end of engineering on these industries, that is, conducting time and motion studies, improving the flow line of activity. We might very well include research on creameries, cheese factories, community soybean crushing plants, tung nut crushing plants, elevators and feed mills, community canneries, locker storage plants, fruit and vegetable storage and packing centers, and others.

This brief discussion shows the highly cooperative nature of our work as well as the possibilities resulting from coordinated effort of our federal and state agricultural research facilities. The importance of engineering in agricultural research is emphasized by a recent statement that 85 per cent of all agricultural research has engineering implications.

Representatives of the other research bureaus of the USDA have stated on several occasions that their work is handicapped by lack of engineering assistance. It seems logical that this is the case in many instances. Possibly there are other fields calling for our cooperation, including adapting many wartime developments to agriculture.

We are now in the midst of the greatest transition in the history of agriculture—a transition that is unending. The farmer's market needs expansion through enlivened demand that can come through new and better products. He has the advantage of a host of new inventions, materials and methods—plant growth regulators, new weed killers, startling new insecticides, improved procedures and soil conservation sections, combine harvesting machines for many crops, and combination seedbed-preparation machines. The farmer deserves and wants improved living conditions for his family and livestock.

Installations for Noting the Water and Thermal Relationships in Soils

By Robert G. White
MEMBER A.S.A.E.

EARLY in 1940 the Michigan Hydrologic Research Project was established at East Lansing as a cooperative study between the U. S. Soil Conservation Service and the Michigan Agricultural Experiment Station. The purpose of this undertaking was to study effect of land use on the hydrology of farm lands under varying types of snow cover and frozen soil. The objectives were: (1) To determine manner in which freezing and thawing of soils on watersheds with varying types of land use contributes to runoff, erosion, and flood flow under northern winter conditions, and (2) to determine the fundamental hydrologic relationships of typical Michigan soils under varying types of land use, with special emphasis upon the movement of water through the soil profile during the fall and winter months.

In order to develop a project of this type successfully, it is necessary to accumulate a variety of data from numerous sources in order that all climatic and hydrologic factors affecting the work might be properly evaluated. The purpose of this paper is to describe the instrumentation, methods, and techniques involved, in order that others working on similar projects might benefit by our experience.

The author wishes to acknowledge that Walter U. Garstka planned and installed the equipment described in this paper. Mr. Garstka was the project supervisor from the inception of the project in 1940 until September 30, 1944.

At the beginning, it was realized that, in order to study the hydrology of farm lands successfully it would be necessary to collect a variety of data on related subjects. The subjects considered to be of major importance were as follows:

1 Precipitation
   (a) Amount and intensity
2 Water losses
   (a) Runoff: amount and rate
   (b) Infiltration: rate
   (c) Evaporation: total and rate
   (d) Transpiration: total and rate
3 Erosion losses
4 Soil moisture
5 Temperature
   (a) Air
   (b) Soil
6 Solar and sky radiation
7 Wind movement
   (a) Velocity and direction
   (b) Total wind movement

It was desired to equip the project in such a manner that as many of the above data as possible could be collected with a minimum requirement of time. The project was organized on the basis of being operated by one man, thus making it necessary to reduce as many of the procedures as possible to mechanical recording processes.

Two cultivated and one wooded watersheds were selected. The cultivated watersheds were located on the south part of the Michigan State College farm near East Lansing, and the wooded watershed was located about ten miles northeast of the College at the Rose Lake Wildlife Experiment Station. Since war restrictions made it impossible to construct a power line to the wooded watershed, that part of the project has not been instrumented in as much detail as the cultivated watersheds have been.

Precipitation. At all watersheds, precipitation is measured by the standard U. S. Weather Bureau type, non-recording rain gage. A 9-in weighing-type recording rain gage is used to determine the intensity of rainfall, and a standard non-recording rain gage equipped with a Nipher shield is used as a supplement to determine the reliability of rain (and particularly snow) measurements under conditions of high wind. For individual periods of snowfall accompanied by high wind velocities, the catch of the shielded gage has been found to be as much as 150 per cent of the non-shielded gage.

Water Losses. Runoff is measured at each watershed by means of a float-type portable water-stage recorder and a 3-H flume. A reinforced concrete approach section was installed at the outlet of each watershed to deliver runoff water to the measuring flume in an orderly manner. The runoff recorder itself was mounted on a metal framework attached directly to the flume, independent of the shelter house. This type of construction was selected to reduce to a minimum the possibility of error in the float zero adjustment.

Because much of the runoff in northern states is caused by snow melt and comes at a time of the year when intermittent freezing and thawing is expected, it was necessary to devise means of applying heat to the flumes to prevent their freezing and choking with ice. Strip heaters were installed beneath the flumes and along the edges so as to warm the bottoms uniformly. The heaters have sufficient capacity to prevent freezing on the floor of the flume, but are not hot enough to warp the metal or open soldered seams.

An electric heater, such as is used for chicken drinking fountains, was suspended in the still well of each flume in such a manner as to permit free float action. This heater was suspended near a small hole which had been drilled in the bottom of the still well to permit it to drain after runoff had ceased. The chicken

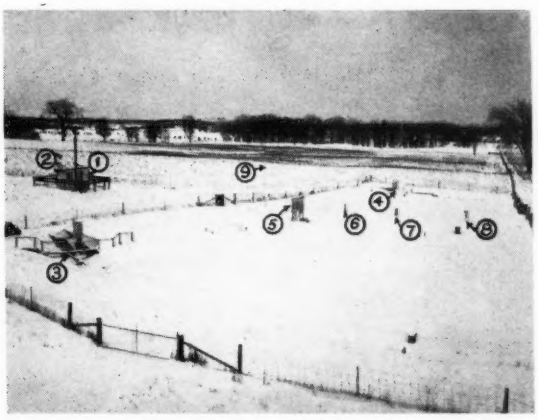


Fig. 1 General view of instrument enclosure and shelter house, looking diagonally across cultivated watersheds: (1) instrument shelter house, (2) pyrheliometer (solar radiation), (3) runoff and silt-measuring station, watershed A, (4) runoff and silt-measuring station, watershed B, (5) weather station, (6) standard USWB rain gage, (7) recording rain gage, (8) standard USWB rain gage with Nipher shield, (9) wind tower

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

ROBERT G. WHITE is project supervisor, Michigan Hydrologic Research Project, Soil Conservation Service, U. S. Department of Agriculture.

water heater is adequate to keep the still well from freezing, but will not melt ice once it has formed.

All heater circuits are connected through two thermostats wired in series and exposed to normal air temperature. One thermostat closes on falling temperatures and operates at 40 F (degrees Fahrenheit). The other thermostat closes on rising temperatures and closes at 20 F. Thus heat is applied to the flumes only at air temperatures between 20 and 40 F. There is no freezing in the flumes at air temperatures of 40 F or above, and all trace of runoff has long since ceased before air temperatures drop to 20 F.

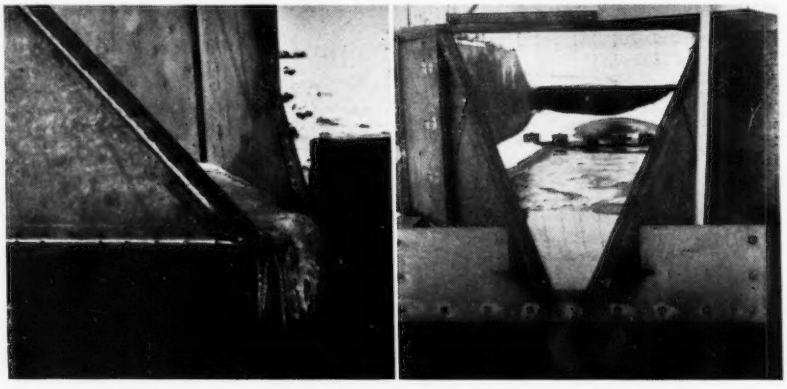


Fig. 3 (Left) Winter runoff causing ice formation in flume prior to installing flume heaters. (Right) Winter runoff after installing flume heaters

Each runoff recorder is equipped with an adjustable float-stop so that the float never drops lower in the still well than its zero point of buoyancy. This float-stop adjustment is equipped with a vernier and can be read to the nearest 0.001 ft. The float-stop is mounted on the base of the runoff recorder and operates on the weight end of the float cable.

Infiltration rates are to be determined by an analysis of the hydrograph of individual rains for each watershed. The rate of evaporation of water under field conditions, and the rate of transpiration of water by plants, can not be successfully measured by a mechanical recording process. It was felt, however, that records of solar and sky radiation, air temperature, humidity, and wind movement could be used as an index of evaporation and transpiration.

Erosion Losses. Any study of the movement of water through or over the soil is influenced to a certain extent by the movement of the soil itself.

At each of the watersheds, runoff water enters a reinforced concrete silt box after passing through the measuring flume. Owing to the size of the watersheds, it was not practical to build silt boxes large enough to hold the total quantity of runoff, so the outlet end of each silt box was equipped with a weir over which runoff could flow after reaching a depth of two feet in the silt box.

A Ramser divisor was installed in the side of each silt box at the level of the weir plate. In this manner, an aliquot sample of the excess runoff going over the weir plate is diverted by the divisor into a catchment tank at the side of the silt box. Total soil loss is determined by analyzing for dry weight per cubic foot the catchment in the auxiliary tank, multiplying that by the total volume of runoff passing over the weir, and adding that to the total dry weight of the soil caught in the silt box.

Soil Moisture. In a study of this type, it is necessary to make soil-moisture determinations accurately and rapidly. Also, it is quite obvious that a means of making determinations must be employed which does not require soil samples. To meet these requirements, the electrical resistance method was selected, making use of the Bouyoucos gypsum block principle[1]*. This principle involves the use of a small block of gypsum cast around two electrodes. When such a porous medium is wetted and placed in the soil, there is a tendency for the water to move from the block to the soil or from the soil to the block until an equilibrium has been reached. At this point, the capillary potential of the soil moisture is equal to that of the block.

The electrical resistance of the gypsum block is dependent primarily upon its moisture content and temperature, and serves as a measure of capillary potential or soil-moisture tension, rather than as a measure of the percentage of moisture in the soil. However, by calibrating the blocks they can be successfully used to determine the per cent of moisture in the soil.

Block resistances vary with temperature as well as moisture, making it necessary to apply temperature corrections to all observed block resistances before they can be converted into per cent of moisture. Since soil temperatures at East Lansing seldom go below 30 F or above 90 F, except for short periods of time in the surface layers, all block readings at this project are corrected to 60 F. This temperature was chosen as the basis for block corrections because it is approximately the midpoint of the soil temperature range. Block temperatures are recorded by means of thermocouples placed in the soil near the block, and will be discussed in more detail later.

Work by Bouyoucos and Mick[1], and later modified by Peele and Beale[3] and by Slater[4], shows that the resistance of the Bouyoucos block varies by an amount equal to the 0.002 power of the observed resistance for each degree Fahrenheit change in temperature. This expression may be stated as

$$R_c = R_o \left[1 + 0.002 \ (t_o - t_c) \right]$$

where R_c is the correct block resistance, R_o is the observed block resistance, t_o is the observed block temperature, and t_c is the temperature to which resistances are being corrected. Since all block readings at this project are corrected to 60 F, the expression used is

$$\text{Log } R_c = \left[1 + 0.002 \ (t_o - 60) \right] \text{Log } R_o$$

It can be seen that, when the observed temperature is 60 F, the coefficient becomes unity and no correction is made. However, when the observed temperature is greater than 60 F, the coefficient is greater than unity and R_c is greater than R_o; but when less than 60 F, the coefficient is less than unity and R_c is less than R_o.

Using the foregoing expression, a series of charts has been prepared from which temperature corrections may be read graphically for temperatures ranging from 25 to 90 F by one-degree intervals. The graphic solution reduces to a minimum the time required to make temperature corrections.

The construction of calibration curves for determining the per cent of moisture from block resistance readings necessitates some rather careful procedures if the resulting curves are to be reliable. In making calibration tests at this project, a sample of soil was obtained from the strata in which each block was to be placed. The soil sample was

*Superscript numbers refer to appended references.

handled carefully so as to result in minimum alteration of natural soil structure.

Each sample was air-dried and placed in a cheesecloth bag which was supported by a wire basket $2\frac{1}{2} \times 3 \times 4\frac{1}{2}$ in in size and made of $\frac{1}{8}$-in mesh hardware cloth. The gypsum block was placed in the center of the mass and the soil gently packed around it. Use of the wire basket assured adequate loss of moisture and a more even distribution of moisture when the mass was allowed to approach stabilization. The soil was exposed on all six sides so that the moisture could be lost from each side to approximately the same degree.

The soil mass was wetted by standing it in about one inch of distilled water for three to six hours, and then in four inches of water overnight. This method of wetting was used to assure a minimum of trapped air in pore spaces. It was then allowed to dry at room temperature for three to four days and was again wetted and dried. The preliminary wetting and drying process was utilized to assist in the establishment of soil structure that approached field conditions. After two wetting and drying cycles, the samples were ready for the calibration process.

The soil was wetted as before, and the excess moisture allowed to drain off. It was then weighed and the resistance of the block measured. The mass was then dried for about 24 hr, and placed in a humidity chamber for 48 to 72 hr to facilitate the establishment of equal moisture conditions throughout. At the end of the period, the sample was weighed and the resistance of the block measured. This drying and equalizing process was continued throughout the desired moisture range.

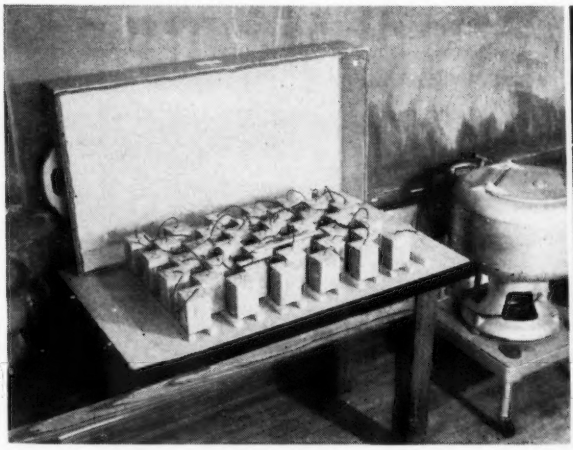
It was felt that at least two complete moisture cycles should be measured in order to obtain a representative distribution of readings over the desired moisture range. This procedure was developed independently, but it is essentially the same as that reported later by Kelly[2]. After an adequate number of determinations had been made, the samples were dried in an oven to obtain the dry weight of the soil. By deducting the weight of the wire basket and the wire leads of the gypsum block, it was a simple matter to calculate the percentage of moisture in the soil at any given total weight. The gypsum block and the cheesecloth were assumed to be included in the soil, and at the same moisture content. This of course is not absolutely true, but the error involved is relatively small and the procedure is well within the limits of accuracy of any other method of determining soil moisture.

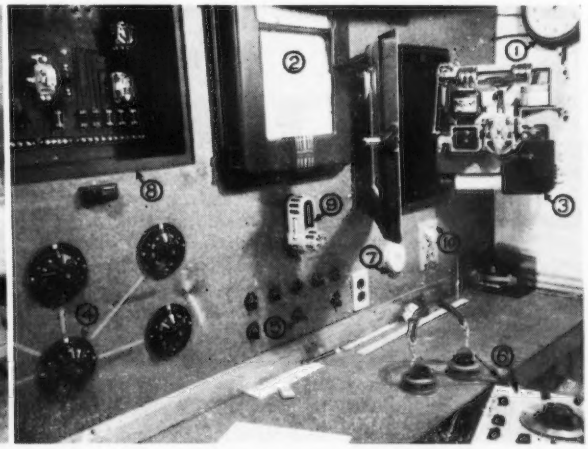
After the calibration tests were completed, the blocks were installed in the field by exposing a vertical section of the soil profile to the desired depth and then inserting the gypsum block intact with the soil in which it was calibrated into the undisturbed soil at the desired depth. The block and soil were packed into the hole so as to assure a good contact with undisturbed soil. After all blocks and thermocouples at one given location had been placed, the backfill was made, returning the soil in the same order in which it had been excavated. Care was taken to compact the backfill thoroughly without disturbing the blocks or thermocouples.

All blocks were wired through the panel at the instrument shelter house by means of underground cable. All cables were placed by Bell Telephone Company cable-laying equipment at a depth well below the range of tillage implements. Inside the instrument shelter house, one lead wire from each block was junctioned into a common lead and run directly to the bridge. By means of the other lead, individual block circuits were wired through a bank of 11-point switches mounted on the instrument panel and connected through a central switch to the bridge. In this manner, only one pair of leads are attached to the bridge, and connection to the individual blocks in the field is by means of switches.

Block resistances are measured by use of the Wheatstone bridge. Since some blocks are located as much as 350 ft from the instrument shelter house, it was found necessary to redesign the recommended bridge and incorporate a system of decade condensers to balance the capacitance of the long leads. A multiple range control was also built into the bridge so that resistances ranging from as low as 100 ohms to as high as several million ohms could be measured.

Temperature. Air temperatures at all watersheds are recorded by means of hygrothermographs, giving a continuous record of air temperature and humidity at approximately 60 in above ground level. Weekly temperature fluctuations are recorded by maximum and minimum registering thermometers to check the accuracy of the hygrothermograph. This equipment is housed in a standard Weather Bureau type shelter house.





Left: Fig. 4 Gypsum blocks in process of being calibrated. Blocks and soil have been placed in cheesecloth bags and are in wire baskets • *Right:* Fig. 5 General view of instrument panel in shelter house at cultivated watersheds: (1) central time clock, (2) recording potentiometer (solar radiation), (3) internal view of soil temperature recorder, (4) thermocouple circuit switches, (5) gypsum-block circuit switches, (6) Wheatstone bridge with earphones, (7) wind mileage totalizer, (8) wiring panel for special circuits, (9) thermostat to control shelter-house temperature, (10) battery charger

Soil temperatures are recorded by means of soil thermographs, by thermocouples, and by the use of thermohms. At the wooded watershed, the three-pen soil thermograph is used for recording soil temperatures. One element is placed six inches above ground to record air temperatures, one is placed one inch below ground, and the third is placed six inches below ground level. Weekly charts provide a continuous record of air and soil temperatures at those levels.

At the cultivated watersheds, thermocouples and thermohms are utilized in determining soil temperatures. Since resistance readings of gypsum blocks must be corrected for temperature before being converted to per cent of moisture, a thermocouple was placed in the soil adjacent to each block. In this manner, it is possible to determine the temperature of each block at the time its resistance is being determined. Copper-constantan thermocouples were selected for this purpose as that combination of metals is best adapted to the range of temperatures normally encountered in soils. The constantan leads from all thermocouples were junctioned into a common constantan wire leading directly to the constantan terminal of the potentiometer in the instrument shelter house. The copper lead from each thermocouple was run directly to the panel in the instrument shelter house where it was connected to a 10-point rotary selector switch. Each rotary selector switch was connected to the copper terminal of the potentiometer by means of a central selector switch. It is needless to say that care must be exercised in making connections and junctions in the thermocouple circuits. All junctions and connections must be copper-to-copper or constantan-to-constantan, shielded by but not separated by solder. If perfect metal to metal contacts are not secured, secondary thermocouple effects will be introduced into the circuit, resulting in improper temperature recordings. Rotary selector switches machined from blocks of copper were used in the copper side of the thermocouple circuits to prevent the introduction of secondary thermocouple effects in the switches.

Temperature determinations are made by the use of a potentiometer equipped with a manual reference junction. A potentiometer was selected having a range of −40 to + 160 F, with a scale calibrated to read directly in degrees F. A copper-constantan thermocouple was attached to the bulb of a mercury thermometer, and the two then packed in about one inch of asbestos waste. This unit was mounted at a convenient point on the instrument panel, and the thermocouple leads connected to the potentiometer through the switch system. Because there was an inch of insulation around the thermometer bulb and thermocouple, it was felt that the temperature of the two would be identical. This test circuit is used as a check on the balance of the potentiometer.

Since soil temperature in the surface layers sometimes fluctuates greatly from one part of the day to another, it was considered desirable to maintain a detailed record of soil temperatures in surface layers. Thermohms were used as a basis for determining these temperatures, which are recorded by a 16-point, automatic-recording resistance thermometer located at the instrument shelter house. This recorder is equipped to handle 16 circuits, recording one circuit per minute. In this manner, each of the 16 circuits is recorded approximately four times per hour. One of the circuits is attached to a test coil that records 32 F when the mechanism is in proper adjustment. One other circuit is utilized to record air temperature six inches above ground level.

During the winter months, it is sometimes difficult to determine just when the soil begins to freeze. The temperature may be recorded as 32 F, but it is not possible to determine from temperature alone if soil is frozen. The gypsum block will respond as a dry block when frozen. Thus when temperatures are recorded in the vicinity of 32 F, one may be sure that high block resistances indicate frozen soil. Gypsum-block resistances may jump from less than 1000 ohms to 150,000 ohms or higher immediately upon freezing.

Solar and Sky Radiation. Solar and sky radiation is the source of external heat energy. This radiation is measured at this project by means of a 10-junction thermoelectric pyrheliometer and is recorded as millivolts by an automatic-recording potentiometer. From the chart, the hourly area under the curve is determined by means of a planimeter, and then converted to gram calories of heat energy per square centimeter.

Since there is no solar and sky radiation at night, an automatic time switch was installed in the power circuit leading to the potentiometer, which stops the recorder each night after sundown and starts it again before sunrise the following morning. Once every 40 min, the potentiometer automatically standardizes its voltage. This standardizing process takes approximately one minute, and to prevent the possibility of the time switch stopping the recorder while in the standardizing circuit, it was necessary to design and install a circuit to by-pass the time switch should it shut off while the recorder was in its standardizing cycle. This by-pass circuit consists of a small mercury switch mounted on an arm which is tilted downward as the recorder drops into the standardizing circuit. The tilting action closes the mercury switch and by-passes the time switch until the recorder completes the standardizing cycle.

Wind Movement. Wind movement is an important factor in evaluating certain hydrologic phenomena, particularly as it influences evaporation and air mass movement.

Wind movement is recorded at the cultivated watersheds by means of an anemometer mounted on a 25-ft wind tower. The anemometer is designed in such a manner that the rotating cups close points momentarily with each 1/60 mile of wind movement. This contact impulse is transmitted by means of a two-way relay to a wind-mileage totalizer and to a wind-direction and velocity recorder.

The wind-mileage totalizer consists primarily of an alarm-clock movement in which the balance wheel and hairspring have been removed and replaced by a small electromagnet. Each time 1/60 mile of wind passes the anemometer cups, a contact is made and the electromagnet permits the totalizer hands to advance the equivalent of one second. With an appropriate dial, the hands indicate total miles of wind movement instead of hours.

The wind direction and velocity recorder records one-minute samples of wind direction and velocity four times per hour. The timing mechanism is driven by a small 110-v synchronous motor to insure the proper timing of the wind samples. One-minute samples are taken, beginning on the hour and at 15, 30, and 45 min after the hour. Since the wind velocity recorder receives impulses every time 1/60 mile of wind passes the tower during the 60-sec sample period, the total number of impulses received during one minute represents wind velocity in miles per hour.

Wind direction is recorded in 45-deg segments by means of a wind vane at the top of the wind tower. The position of the wind vane at the time the one-minute sample is taken determines which directional contacts are closed.

Since wind movement in woodland cannot be reliably measured, except at altitudes well above the level of the tree canopy, a wind tower has been placed near the office of the Rose Lake Wildlife Experiment Station, approximately one mile from the wooded watershed. Total wind

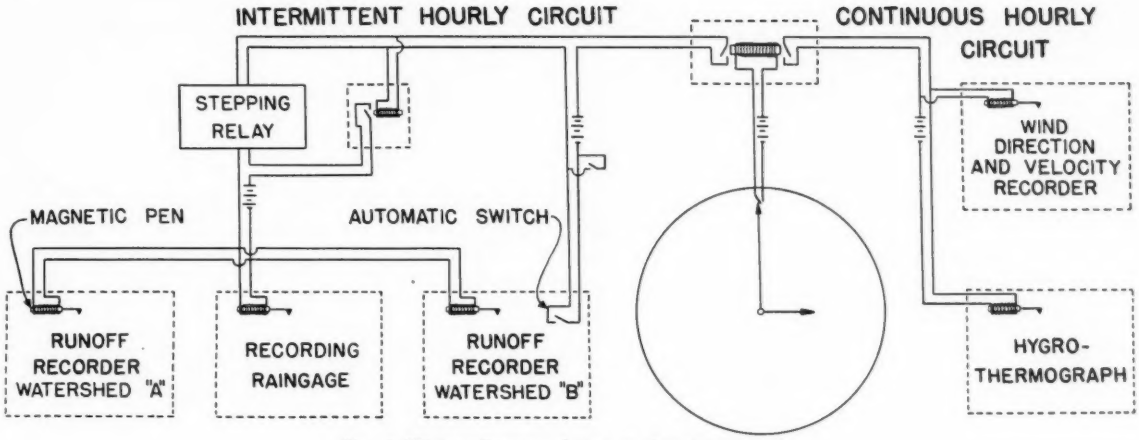


Fig. 6 Wiring diagram of time-synchronizing circuits

movement is recorded at this station, but wind direction and velocity are not recorded.

Time Synchronizing Circuits. One of the major problems of studying the records of rainfall and runoff and in developing a hydrograph from these data is the lack of uniformity of timing in the various clocks. A rather unique plan has been worked out whereby time markings are automatically placed on the charts from a central time clock. This guarantees a uniformity of time markings on all charts. The wiring diagram for the time-marking circuits is shown in Fig. 6 and will be discussed briefly.

Time marks are placed on the charts by means of auxiliary magnetic pens mounted on special brackets on each recording instrument. The pens are mounted so as to permit free action of the instrument pen over the full chart range. The magnetic pen makes a horizontal line on the chart, and when excited by an electrical current, it makes a short vertical mark about $\frac{1}{8}$ in in length. This mark indicates the "hour" on the chart, and indicates the position of the instrument pen at that given time, provided the instrument pen and the magnetic pen are properly synchronized. Since the wind direction and velocity recorder and the hygrothermograph use weekly charts, it was desired to have continuous hourly markings on these charts. However, the recording rain gage and runoff recorders use 12-hr charts, and, as these charts are not regularly changed daily, it was desired to have these recorders in an intermittent circuit so that time marks would be placed on their charts only during periods of runoff.

The desired circuits were secured by placing a small spring switch at "12" on an electric clock in such a manner that the minute hand forces the switch into the closed position for about 15 sec every hour on the hour. The circuit is energized by a six-volt battery and operates a two-way relay.

The continuous hourly marking circuit leads off one side of the two-way relay and is also energized by a six-volt battery, causing hourly time markings on all weekly charts.

The intermittent hourly circuit leads off the other side of the two-way relay and is used to operate a stop-on-contact-point type, 24-point stepping relay. This circuit is likewise energized by a six-volt battery. In series with the stepping relay is an automatic closing switch located at the runoff recorder at watershed B. The automatic closing switch consists of a small mercury switch mounted on a pivot in such a manner that the circuit is held "open" until runoff starts. As the water stage at runoff recorder B reaches a depth of 0.02 ft, the switch automatically closes and remains closed until reset by hand. Thus there is an open circuit to the stepping relay until runoff starts. It is to be kept in mind that the stepping relay advances only one step each time its circuit is activated, so it takes 24 hr for it to make one complete revolution after runoff starts. The automatic switch was located at watershed B instead of watershed A because in practically all cases, runoff starts at watershed B before it does at A. A small manual switch is also mounted on the instrument panel to by-pass the automatic switch so that the stepping relay circuit can be tested from the instrument panel without disturbing the automatic switch at watershed B.

On the stepping relay, 11 consecutive points of the 24 points are wired in series with the circuits leading to the magnetic pens on the recording rain gage and runoff recorders. Since these recorders all use 12-hr charts, there will be 11 consecutive time marks put on the chart after runoff starts, leaving one unmarked hour on the charts to indicate the approximate time at which runoff started. The stepping relay will then advance over the 13 hourly blank points before it completes one cycle and starts remarking the charts. Normally, in this 24-hr period, an attendant has time to change the charts, reset the automatic switch and reset the stepping relay to its zero position. After this has been done, there will be no more time marks on the 12-hr charts until the next period of runoff.

Since the stop-on-contact-point type of stepping relay was used, it was necessary to provide a method of breaking the circuit between the stepping relay contact points and the magnetic pens. This was accomplished by wiring in parallel with the stepping relay a single-contact relay. The contact points of the single-contact relay were wired in series with the contact points of the stepping relay and the magnetic pens. In this manner, the circuit between the stepping relay and the magnetic pens is broken at all times except for the 15-sec intervals when there is an activating current into the stepping relay.

Originally an attempt was made to use a stop-between-contact-points type of stepping relay, but it was found that the brief instant that the moving finger of the stepping relay was on the contact point was not sufficient to permit positive action of the magnetic pens.

General. With the installations described in this paper, it has been possible for one man to collect data at this project with a minimum requirement of time. An average of 2 to $2\frac{1}{2}$ hr per day is required, or approximately 16 hr per week. This does not, however, include time required to clean or adjust equipment, clean *(Continued on page 32)*

Application of Stream Gaging to the Agricultural Use of Small Streams and Ponds

By M. T. Thomson
ASSOCIATE MEMBER A.S.A.E.

STUDIES by agricultural authorities in Georgia have indicated that some 30,000 farm ponds may be constructed in the near future, many of them for irrigation or for water for livestock. This is a rather astonishing fact for a state in the humid region of the country where the annual rainfall is 40 in or more, yet it is readily understandable to those familiar with water-resources problems in the Southeast. All too often excessive rainfall occurs in combination with destructive storms and causes serious damage. On the other hand, the precipitation may occur at such infrequent intervals as to cause serious droughts. The frequency and severity of these droughts are shown by records of streamflow.

During the periods when the flow of larger streams is low, the smaller streams in the region are generally dry or nearly so, In most years a long and severe drought occurs in the fall months. The fall droughts cause severe problems, particularly for the livestock-raising industry which has to provide water for the livestock and also for maintaining year-round forage. In about one-half of the years a shorter drought occurs in the spring or early summer. This is the drought which causes trouble for gardens and truck crops; yet it is generally brief and not very severe, so that relatively little water for supplemental use need be supplied.

Water shortages affect not only agriculture but also the industries that use agricultural products. For example, meat-packing plants, dairies, and milk-drying plants require an abundance of water. Surveys by Georgia's agricultural and industrial board have shown widespread interest among the smaller communities in starting canning plants. A canning plant needs not only an adequate water supply for itself, but a dependable source of farm products. Usually the canneries enter into contract with farmers for the delivery of a definite number of bushels of farm products. With our erratic climate it may be difficult or impossible to make delivery of a truck crop in accordance with the guarantee, but with supplemental irrigation it should be possible to make dependable deliveries.

Almost any farm in Georgia has possibilities of developing an adequate water supply for the supplemental irrigation of a limited acreage or for the use of a dairy herd. The question is whether there will be a profit from the development. This is an engineering problem and for its solution one must have a dependable estimate of the available water resources, as well as the demands that are to be made upon it.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Atlanta, Ga., February, 1945.

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The Water Resources Branch of the U. S. Geological Survey is authorized to investigate the water supply of the country and to publish the information for public use. It is recognized that, in water-resources investigations, a survey of conditions can not be made on short notice, for it takes time to collect records which will be reliable indicators of future conditions. Therefore, it is our endeavor to collect the necessary records prior to the need for them. In recognition of the need of reliable information about the flow of small streams in Georgia, Garland Peyton, director of the state Department of Mines, Mining and Geology, the agency with which the Geological Survey cooperates on water-resources investigations, has authorized a pilot program of research on small streams. This program has provided a number of gaging stations on small streams and, in addition, measurements of the streams at various points within selected representative basins. This paper is based upon some of the current findings of this program and is intended to show the general principles of the investigation and some preliminary results.

This project is not set up to study rainfall-runoff relations or the effect of man-made alterations on the surface of the earth. It is an effort to find out how much water runs off from any stream basin by measuring the runoff directly. In recent years much effort and money have been expended in the study of rainfall-runoff relations under varying conditions. It is my belief that such investigations, however useful their results may be for other purposes, will not provide truly reliable criteria for the determination of runoff on a wide scale without the basic information of actual direct measurements of runoff.

To begin with, there are already available runoff data for the principal streams. More than 100 gaging stations are now in operation in Georgia. Another 100 sites have had gaging-station records in the past and several hundred other streams have been measured during drought conditions. Unfortunately there are not enough gaging stations on small streams, but that deficiency is gradually being overcome.

Where flow was found in the basin survey of Tired Creek in Grady County, the discharge varied from zero up to 1.21 sec-ft per sq. mi. These figures correspond to those at the gaging stations for 80 per cent duration of time for the calendar year 1944. This means that the indicated discharge was equaled or exceeded 80 per cent of the time in 1944, and that the streamflow was less for the remainder of the time during that year.

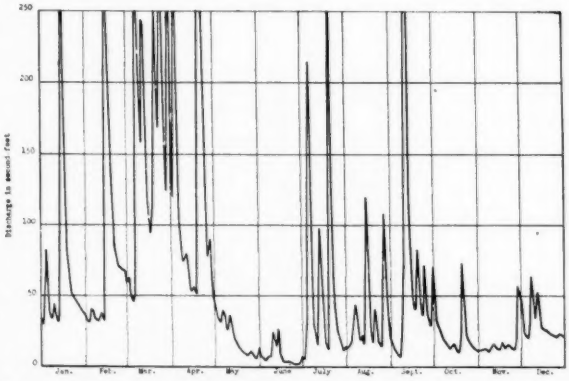
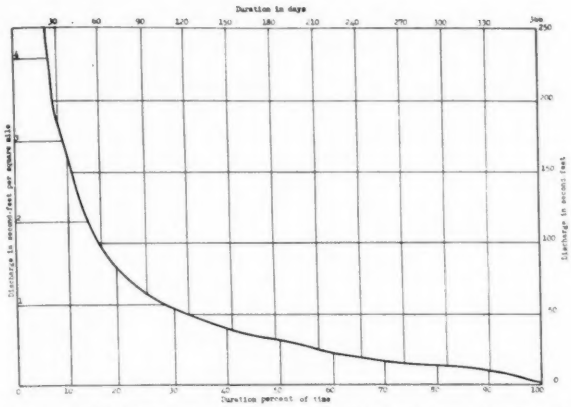


Fig. 1 A discharge hydrograph of the Tired Creek basin near Cairo, Georgia, for the calendar year 1944

In studying the results of the measurements it was found that the measurements of individual streams draining approximately 2 sq mi or more were reasonably consistent, but that those with



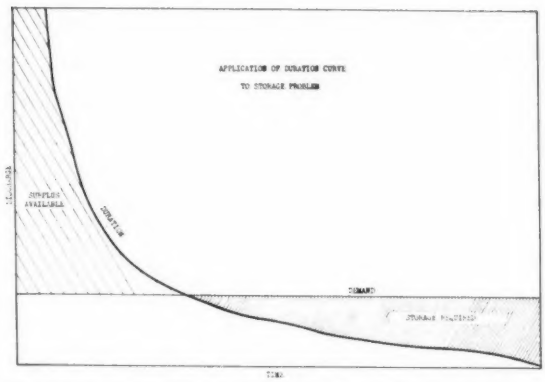


Fig. 2 (Left) Duration curve for the Tired Creek basin during the calendar year 1944. Mean discharge, 66.7 sec-ft. Drainage area, 57.3 sq mi • Fig. 3 (Right) This graph shows the application of the duration curve to storage problems

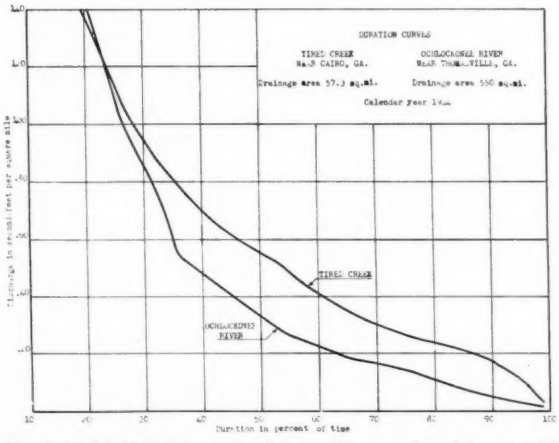
smaller drainage areas varied greatly. The flow in each individual stream tends to be uniform, although some of the streams carry more water in proportion to their drainage areas than others. The cause of the variation is not readily apparent, and can not be explained by rainfall or temperature differences, or difference in soil types or cover, so far as information is available. The local topography, the height of the water table, and the nature of the underlying geologic formation possibly may be found responsible for the differences when all the facts are known.

Undoubtedly if all the variables were known the various streamflows could be explained. However, the many factors are not determined; their relation to runoff is not yet known and probably will not be known until the runoff is measured in order to establish the relations. On the other hand, we are collecting factual information about streamflow itself, and from the measurements of flow, reliable estimates can be derived to serve the purpose of designing ponds.

In streams draining small areas, the size of the drainage area is one of the most important factors affecting the discharge. As one progresses upstream on the many trickles which form the streams he comes to a point where there is a spring, or seep, above which there is no flow in the channel and eventually not even a channel. Above the spring the stream is commonly called a wet-weather stream. Any roadside ditch is an example of this type of stream. The water it carries is only surface runoff and a small amount of subsurface flow. It has little or none of the groundwater contribution that is termed base flow. In small streams the proportion of the area which contributes no base flow becomes large, with the result that it materially affects the proportionate amount of base flow in the stream. On larger streams the proportion of the dry area to the total area tends to remain practically a constant.

It has already been stated that the measurements in the Tired Creek basin represented the flow at about 80 per cent duration of time. This statement is based on the record at the index gaging station on Tired Creek near Cairo. Fig. 1 shows the variation in the daily flow at that gaging station. This diagram is obtained by plotting the records of the daily discharges, which is the type of data collected and published by the Geological Survey; the diagram is commonly called a discharge hydrograph. The very high flood peaks are not shown on the diagram because the scale of the hydrograph would have to be greatly reduced to bring them within the limits of the diagram. As none of this discussion is particularly concerned with flood flows, the flood peaks and the parts of some duration curves pertaining to flood flows have not been shown.

The discharge hydrograph shows the actual order of occurrences, but to simplify its use hydraulic engineers rearrange the data in the form of a duration curve. This is done by moving all the high days to the left and all the low days to the right and rearranging them in order of magni-



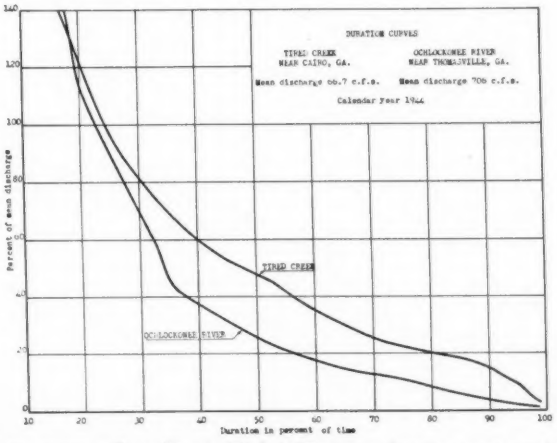
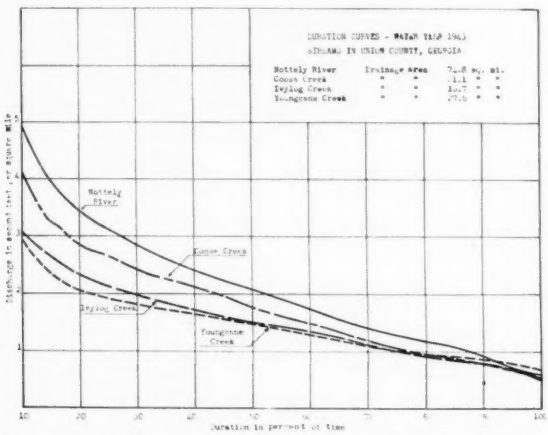


Fig. 4 (Left) Duration curves for two streams plotted in second-feet per square mile • Fig. 5 (Right) The same duration curves as in Fig. 4 plotted in per cent of mean discharge



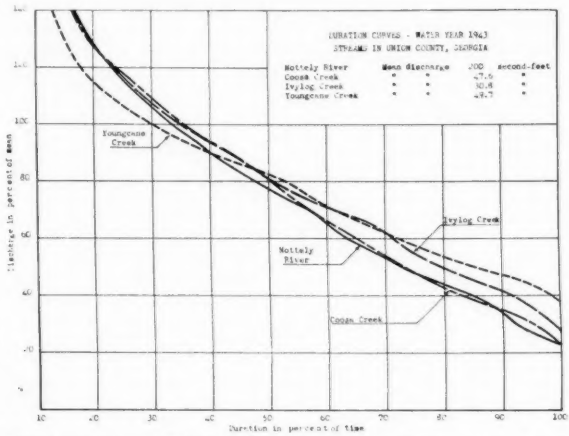


Fig. 6 (Left) Duration curves for four streams in Union County, Georgia • Fig. 7 (Right) The same duration curves as in Fig. 6 plotted in per cent of mean discharge

tude. The result of this procedure is shown by the curve in Fig. 2. For ready use the discharge is expressed in second-feet per square mile, or in per cent of mean discharge, and the time is expressed in per cent rather than in days. The curve, however, is the same regardless of the terms used.

The significance of the duration curve in storage problems is shown in Fig. 3. When the demand is determined, the storage requirement is the area between the lines at the right. The excess water in wet periods is shown between the lines at the left. No scales are shown, but in any plotting of rate of flow against time an area represents volume. The engineer in using the duration curve planimeters the areas he determines and converts the area to volume — gallons, cubic feet, or acre-feet, according to the terms and scales used in his plotting.

In important structures more refined studies are made on hydrographs or mass curves, but they need not be discussed at this point except to say that they can be developed, if necessary, by the same process as is used for duration curves. The big advantage of the duration curve lies in its simple form and the fact that temporary discrepancies due to spotty rains or other irregularities will tend to be smoothed out.

If we examine the duration curves for gaging stations in various parts of Georgia, we find considerable variation in them. We can not expect close agreement of flow between streams that are widely separated or in different geologic provinces. Fig. 4 shows the duration curves for two streams, one of which is tributary to the other. Both lie in the same geologic province. The comparison between the curves is not favorable because the Ochlockonee River is somewhat too large to give comparable runoff conditions. In Fig. 4 the duration curves are plotted in second-feet per square mile. Fig. 5 shows the same duration curves plotted in per cent of mean discharge. The pairs of curves in each of these diagrams have much the same relation to each other.

Fig. 6 shows duration curves for four streams in Union County in north Georgia. This county is mountainous, with variation in rainfall over the several basins. Nevertheless there is a similar pattern to the several duration curves. Fig. 7 shows the same duration curves plotted in per cent of mean discharge. The similarity of the curves is even more apparent when plotted in this manner. These streams are all small and their basins are close together, so that the conditions governing runoff are similar. It is evident that, if one of these duration curves is available, the others could be derived with fair accuracy if a few points on them could be obtained from occasional measurements.

This principle is the basis of the basin-wide surveys which are now being made. The first essential is a gaging station on a typical small stream. The record at this gaging station provides the relationship between discharge and time, that is, the duration curve. Measurements of the ungaged streams can then be made when base-flow conditions exist, and the relation of the measured discharge to time can be derived from the simultaneous discharge at the gaging station. With one such measurement made on the ungaged stream an approximate duration curve can be drawn. Several measurements at varying discharges should give a fairly reliable duration curve. These measurements must be made when base-flow conditions exist. The presence of surface runoff in either of the streams will make the results unreliable unless interpreted by an experienced hydrologist.

Verification of the accuracy of this process is difficult because there are few instances of two or more gaging stations on small streams in close proximity. The favorable results obtained from the available records that have been examined indicate that, for perennial streams, reasonably accurate results may be expected. In fact, the principle is the same as is commonly used in estimates of streamflow at sites some distance removed *(Continued on page 32)*

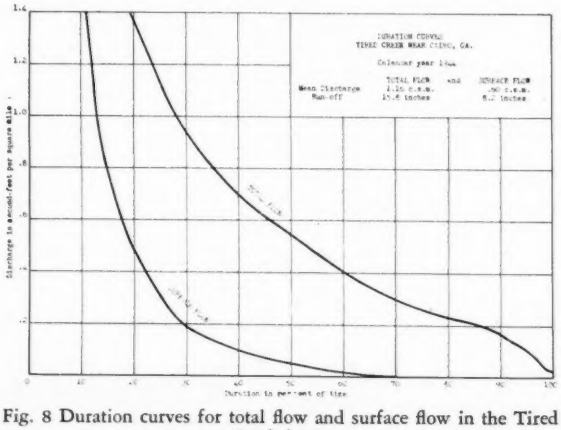


Fig. 8 Duration curves for total flow and surface flow in the Tired Creek basin

A New Portable Field Water Meter and New Furrow Water Meter

By C. N. Johnston
MEMBER A.S.A.E.

A PORTABLE field water meter has been designed that is sufficiently simple to be easily constructed by anyone, but which is quite accurate if made to the specified dimensions. It has been put to use for research work when made of wood and also when constructed of sheet metal entirely. The only item that need be purchased, if a small amount of wood or sheet metal is on hand, is a recorder unit or head with a case for a standard domestic water meter. This item sells for about $3.50. The sketches herewith present details of the wooden meter. When sheet metal is used, the inside dimensions of the various parts of the box are adhered to in order to reproduce the internal areas given for the wooden design. Fig. 1 illustrates the meter in place on the side of a ditch, ready to meter the water delivered to the field. It is shown held in place to the bulkhead by two bolts with tightening nuts in the "view from above", and is shown seated on a rubber or any soft-sealing surface on the bottom edge in the "side view". The tightening of the nuts on the bolts forces the tapered edge of the meter box into the correspondingly tapered seats on the bulkhead effecting a water-tight seal. The assembled meter alone is given in Fig. 2 in greater detail. The dimension "b" is the thickness of the wood used in construction, presumably about ¾ in or the finished thickness of 1x12-in or 1x10-in lumber. In some dimensions given, "b" is added and in others, "b" is subtracted. These plus or minus values are the corrections that the constructor will have to make in dimensioning the parts to complete the reproduction. These slotted strap irons on the meter assembly determine the location of bolts on the bulkhead, or bulkheads. Correspondingly the tapered-edge seats on the bulkhead must be so located that the vertical seal faces close before the meter frame butts up against the bulkhead. It is obvious that the faces on the tapered-seal strips must be plane surfaces on both the meter and the bulkhead.

The moving and recording portion of the meter is detailed in Fig. 3 which is an assembly drawing showing all parts in place. It also shows the concrete throat not given in Fig. 2. This concrete throat is hand-surfaced to give a smooth throat all the way around the inside of the tray, between the top inside face of the tray and the metal throat in the circular hole in the floor of the tray. It shows also this 2-in-wide metal throat that surrounds the impeller with a maximum clearance of ⅛ in. It is tacked to the hole cut in the bottom of the tray, and the hole must be finished to just fit the outside of the metal throat. Small nails can be used to join the metal throat to the wood-hole sides. The location of the upper and lower bearings is obtained by adjustments when the box is completed, so the impeller is centered in the metal throat, makes no contact when turned, and so the shaft is normal to the floor. The lower bearing on the rotating axis (Fig. 3) is simply a tapered stationary shaft seating in a small hole drilled or countersunk in the center of the axis shaft. The stationary tapered pedestal is soldered to the base or turned on a lathe out of larger stock which forms the base. The rotating rod itself should not be smaller than the ¼-in diameter specified or it will be too limber. The impeller vanes are made by cutting a sheet metal disk from the circumference on six evenly spaced radial lines to within ½ in of the center giving each vane a uniform twist so the distance between the outer edges

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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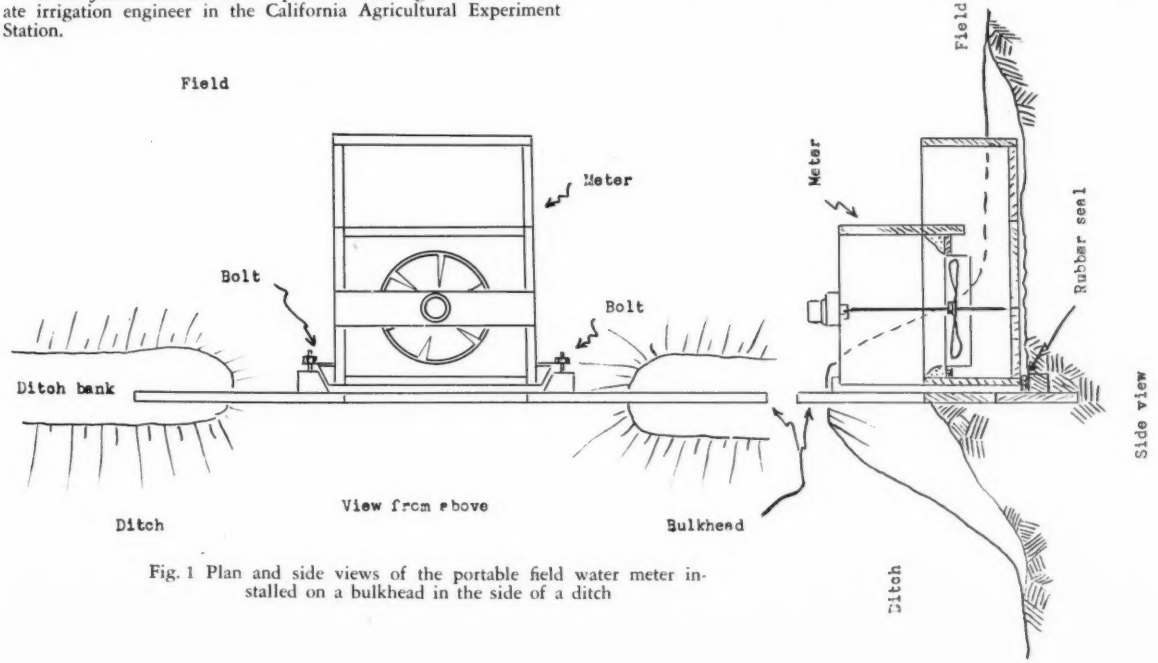
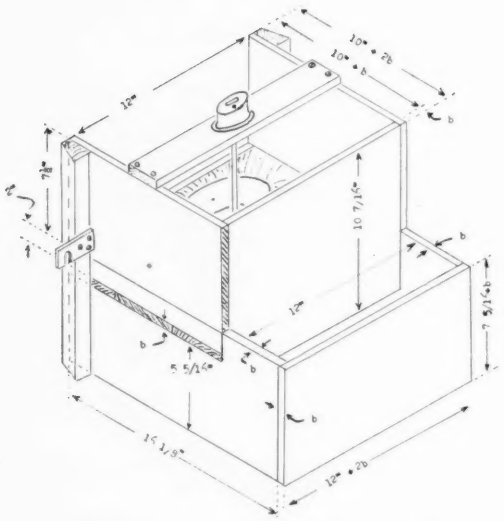
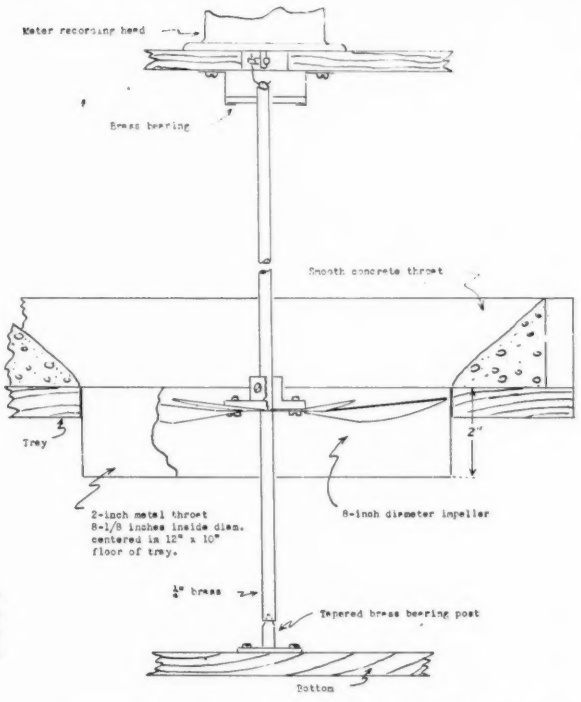


Fig. 1 Plan and side views of the portable field water meter installed on a bulkhead in the side of a ditch





Above: Fig. 2 Dimensioned detail of the portable field water meter for use with wood having thickness "b" (Thickness "b" may be neglected if sheet metal is used.) • *Right:* Fig. 3 This shows rotor and shaft assembly of field meter in place within sectional portion of boxlike housing

becomes ¾ in. This standard dimension must be kept. The direction of twist is determined by the desired rotation. The upper edge of the vanes moves forward around the central shaft. The hub that supports the impeller has a setscrew in it for pinning the impeller to the shaft. This hub may be eliminated by soldering the impeller onto the shaft in a true position so the top edges of the impeller blades will not sweep higher than ⅛ to ¼ in below the top of the metal throat line.

The upper bearing is kept thin (not over ⅛ in) to reduce friction and is centered by trial when the meter assembly is completed. Details of its construction are immaterial and the unit illustrated is a simple one to follow. The paper clip or stiff wire at the top of the revolving shaft is the rotating portion of a flexible joint at the recorder shaft. On the countershaft is soldered a light narrow metal strip or a wire bent so it will retain the end of the paper clip loosely as shown. Any other flexible coupling that might be devised with small friction-consuming characteristics would be as satisfactory.

A meter made to the above specifications should be calibrated against some reliable water-metering device before being put to use, but lacking the facilities to make a calibration run, one can put the unit into operation assuming that each revolution of the meter equals about 0.45 gal delivered.

Several bulkheads can be prepared to receive the meter and it can be moved from one to the other as desired.

Results from a typical calibration test from one of these meters are given in graphical form in Fig. 4. The basic test data are presented in the sloping diagonal line joining the cross marks and labeled "GPM-RPM". The curve joining the circled points and labeled "GPM-gal/rev" is derived from the "GPM-RPM" curve. The average line labeled "Average .425" is the gallons per revolution that approximates this slightly varying value for the flow rates 20 gpm upward. The use of a constant value for gallons per revolution will cause no serious error if the flow is over 20 gpm; above that rate varying-flow rates accumulate accurately on the recorder.

Furrow Water Meter. For some work, the 8-in throat-size meter just described may be too large, as in the case where furrows are being irrigated with very small streams of water. A modification of the 8-in portable meter is illustrated in Fig. 5. The impeller here is 4 in in diameter and the housing is made from two tin cans or the equivalent. They are joined at the bottom inch or inch and a half by soldering or otherwise forming a seal along the edges of the adjoining opened sides. The direction of flow is the reverse in this 4-in model of that for the 8-in previously described and the rotor actuates the recorder shaft through a star wheel rather than directly. The star wheel supplies a gear reduction between the rotor shaft and the recorder lessening the drag on the rotor shaft. By keeping the effect of friction down, the small torque of the 4-in rotor with small flow is used most efficiently. Because the construction of this meter is quite similar to that of the 8-in described

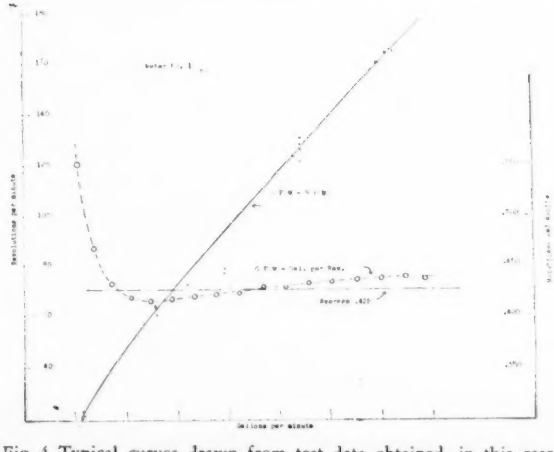


Fig. 4 Typical curves drawn from test data obtained, in this case, from test meter No. 1

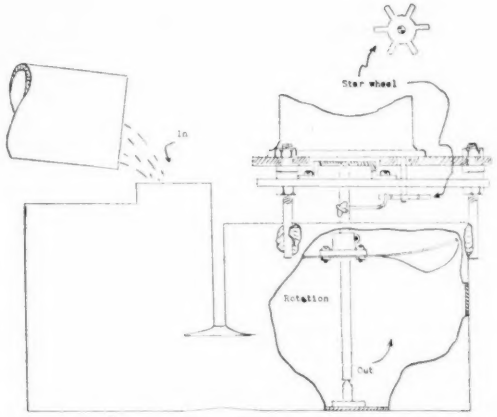


Fig. 5 Assembly drawing of furrow water meter made up by using tin cans as housing or shells. Cutaway view shows rotor assembly construction to be similar to that of the field water meter. The star-wheel drive for the recorder head makes the use of a 4-in impeller possible

in detail, no further description will be undertaken. Close-running fits between impeller and the housing throat are desirable. The operating range of this meter lies between 2 or 3 gpm up to 20 or 30 gpm. The unit passes about 0.25 gal per revolution of the recorder when using a 6-arm star wheel and with a 3/16-in pitch, or separation to the impeller blades at the outer circumference. The unit can be calibrated using a garden hose and weighing the throughput on any available scales. Each gallon of water weighs 8.33 lb at normal temperatures; so, from the weight, the gallons can be found, and if the time taken to accumulate that weight of water is known, the gallons per minute can be calculated simply, as well as the revolutions per minute of the counter. The gallons per revolution equal the gpm ÷ rpm for any given flow and is almost a constant through the operational range above about 3 gpm. Below that minimum flow, friction consumes much of the limited torque available.

Trash and grit should be screened out of the intake of such a small meter to assure steady performance. Fig. 6 gives the performance of two of these small meters under test. The all-iron unit was made from standard iron pipe sections and had a machined throat within which the impeller turned freely. The curves in Fig. 6 correspond to those given in Fig. 4 for the 8-in field meter.

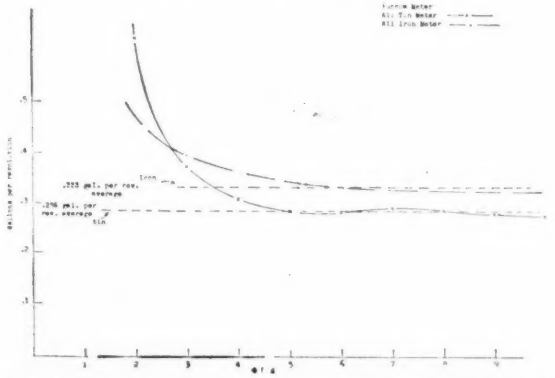


Fig. 6 Final usable results from testing two meters, one with the case made from tin cans and the other with the case made from welded and machined iron pipe pieces. The impeller and other parts were identical otherwise

A New Priming Valve for Portable Siphons

By C. N. Johnston

FARM labor in California objected to the additional stooping required to prime the standard 2-in siphons by immersion. Instead they put one end of the siphon in the ditch and, with the hand sealing the other end, made two or three quick lateral thrusts of the siphon. These thrusts are sufficient to surge the ditch water up into the siphon filling it. The hand acts as a valve releasing the air compressed by each thrust. The operation is as quick if not quicker than would be possible by simple submersion and sealed removal of one end of the siphon.

Siphon sizes above 2 in are too large to be covered by the hand, and canvas sleeves are usually attached to seal the outlet end of the tubes. These sleeves are twisted or rolled up at the end after the whole tube has been submerged. The folded canvas acts as a seal while that end of the siphon is lifted over the ditch bank and lowered to the field level. This latter process is relatively slow and many canvas sleeves are required.

A valve (Fig. 1) that reproduces the operation of the hand on the 2-in siphon, but for application to any size, has been tested satisfactorily recently in the Irrigation Division of the University of California at Davis. One such valve could be used on any number of siphons of that given size. As is apparent from Fig. 1, the valve is essentially a tapered plug, b, covered with a sealing material, c, such as sheet rubber, and having a disk-type valve on its outer surface. This disk, d, is lightly spring-loaded to assist in mak-

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

C. N. JOHNSTON is associate irrigation engineer and assistant professor of irrigation in the California Agricultural Experiment Station.

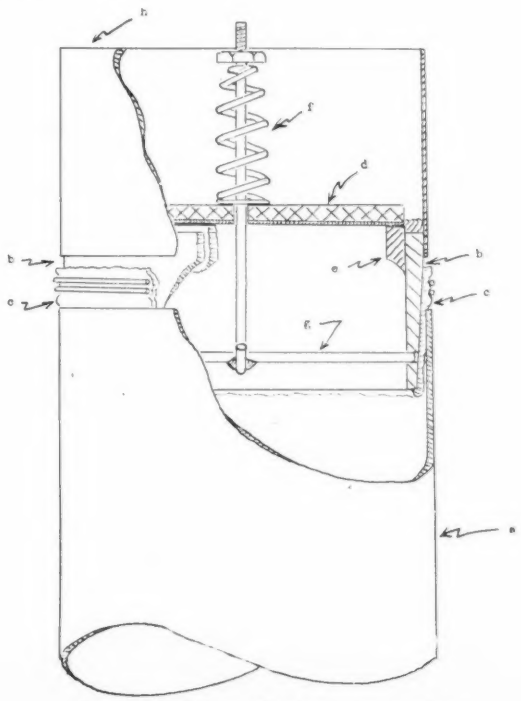


Fig. 1 Detail view of siphon priming valve

ing the seal between the disk and the valve seat, e. The shroud, h, serves two purposes: it protects the loading spring, f, and its guide shaft from injury and further protects the operator from repeated wettings so long as he stays away from the front end of the siphon. The discharge from the disk valve is normal to the length of the siphon without the shroud.

The valve is useful as a starting device for siphon sizes from 2 through 4 in using the lateral thrust motion to surge the supply into the tube. Above 4-in sizes, the weight of the siphon becomes too great for hand surging. One valve of suitable size could replace the multiple canvas sleeves used to seal large diameter siphons primed by the submerge then seal then lift-out method. They could also be used on stationary siphons when there was no water seal at the discharge end at the time priming operations commenced, if the disk is seated tightly first.

The valves made so far used the following materials for the various parts, but substitutions are in order anywhere to suit local supply. Using the letters in Fig. 1,

b, A piece of standard pipe tapered on the outside. Size used depends on siphon to be equipped.
c, Tire inner tube using enough turns to make seal over b.
d, Masonite, 3/16 in to ¼ in, tempered. Could use metal. Rubber face glued to seat side of d.
e, Valve seat made from short section of standard pipe machined to fit inside of b and to give true seat for valve disk.
f, Spring (brass most satisfactory) — very light loading needed. Adjusting nut on centering shaft.
g, Cross tie located in b. Provides point for fastening spring load centering shaft. One-eighth inch to ¼ in brass suitable.
h, Thin sheet iron or equivalent.

There would appear to be possibilities in the field of plastics for the molding of plastic valves to be used at least with the plastic siphons that are being produced.

Farm Dehydrators

(Continued from page 16)

laws which, if correctly applied, produce the proper results, and we may conclude that there is a definite correlation between the fruit to be dried and the heat and air to dry it — a correlation that controls dehydrator design and influences dehydrator operation.

It is more than a structure or a machine, it is a piece of processing equipment in which there must be a balance between the condition of the fruit, weather, labor, fruit handling and processing, fuel and power, quality of final product, load factor and costs. If its operation is to be a success to the farmer, it must pay its own way in labor saving and financial profit.

Water and Thermal Relationships in Soils

(Continued from page 25)

silt boxes, or to process or analyze data. The time involved in collecting data is exceedingly small when one considers that the following data are collected:

1 Daily: (a) Rainfall records at three locations; (b) runoff records at three locations; (c) a total of 44 soil moisture determinations at seven locations, at depths ranging from 1 to 60 in; (d) a total of 34 soil-temperature determinations at seven locations, at depths ranging from 1 to 60 in.

2 Weekly: (a) continuous air temperature and humidity records at two locations; (b) continuous soil-temperature records at one location, at - and 6-in depths; (c) soil-temperature records for 16 points, recorded 90 times per day; (d) continuous record of total solar and sky radiation.

This routine collection of data can be handled by anyone who can qualify for a P-1 civil service position, or can qualify for an instructor's rating at a college or university. Such a person, however, would not be qualified to make repairs or adjustments or otherwise service the recording equipment. Under such a setup, the total annual cost of collecting the data would be approximately $800. Considering only that data which is collected daily, it would be a full-time job for one man to collect this data by means heretofore utilized. This represents a savings of approximately $1700 per year in the labor costs for collecting data. This savings in salary would be a 4 per cent return on an investment of over $40,000, which is considerably greater than the cost of setting up this project.

As an illustration of the type of data collected with the installations described in this paper, reference is made to "Hydrology of Small Watersheds under Winter Conditions of Snow Cover and Frozen Soil", by Walter U. Garstka, American Geophysical Union Transactions of 1944, part VI, page 838.

REFERENCES

1 Bouyoucos, G. J., and A. H. Mick, "An Electrical Resistance Method for the Continuous Measurement of Soil Moisture under Field Conditions," Michigan Agricultural Experiment Station Technical Bulletin 172 (1940).

2 Kelly, Omer J., "A Rapid Method of Calibrating Various Instruments for Measuring Soil Moisture in Situ," Soil Science, vol. 58, pp. 433-40 (1944).

3 Peele, T. C. and O. W. Beale, "Relation of Soil Moisture Content to Electrical Resistance of Bouyoucos Blocks," unpublished report.

4 Slater, C. S. Correspondence with Walter U. Gartska, (Jan. 2, 1943).

Application of Stream Gaging to Small Streams and Ponds

(Continued from page 28)

from gaging stations. It is customary on larger streams to assume runoff proportional to the drainage area. On very small streams the runoff will be proportional to the drainage area to some extent, but not as much so as on larger streams. If streamflows were proportional, all the streams would go dry at the same time. We know that, in general, the tiny headwater streams and the minor tributaries go dry before larger streams do. This is because of the presence of proportionally more base-flow in the larger streams. Thus, in estimating a duration curve for an ungaged stream, there should be a tendency for the curves to be parallel rather than strictly proportional.

If we attempt to derive a duration curve for a very small drainage basin where there is little or no base flow, we should find some better process of deriving the duration curve than by the use of the assumption that the runoff is proportional to the drainage area. If we have a hydrograph of a small stream, it is not difficult to separate on the hydrograph the surface runoff from the base flow. This has been done on the Tired Creek hydrograph for the calendar year 1944 and the duration curve for surface flow is shown in Fig. 8. Surface flow is considered to be the flow which takes place in wet-weather streams. It is by no means as great as the flow below the point where springs occur. It consists of overland runoff and some short-time subsurface seepage. With this pair of curves based on the gaging-station record and a few measurements at the ungaged site, the engineer can draw in his duration curve and proceed with some confidence on his design of a storage pond.

Obviously, streams which show a much higher rate of base-flow runoff than that of the index station will also have a greater annual flow, as *(Continued on page 34)*

Imagineering—Radiation on the Farm of Tomorrow

By L. C. Porter and G. F. Prideaux
FELLOW A.S.A.E. MEMBER A.S.A.E.

WHILE house lighting of today is much better than that of our grandparents', our rooms are still cluttered with floorlamps, table lamps, wall brackets, center fixtures, etc., few of which are ornaments of great beauty, and they take up valuable space and require more or less labor for cleaning. At best the result is rather spotty lighting.

Sooner or later all these excess accoutrements may disappear from the home. You may comment that the present fluorescent fixtures are more bulky and look even more like something for the scrap drive than does our present incandescent lamp equipment. With that, we'll agree. The introduction of circular fluorescent tubes makes possible very attractive and efficient floor and table fixtures. So far very little effort has been put into adapting fluorescent lighting to the home. There is no reason why it cannot be made attractive by being built into coves or luminous panels in walls and ceilings. It would be a relatively simple matter to light such flush luminous panels so that both the intensity and color can be changed at will. Perhaps the atmosphere created by a warm summer sunset might be welcome on a chilly winter day, or a soft moonlight effect in the evening for a radio or television program. The fresh cool north sky color of lighting might be desirable at other times. All of these, or any combination, are not too difficult to obtain. They will be tuned in as simply as today's modern radio tunes in a station.

Why should the windows be used for lighting during the day and be useless at night? There is already available glass which when it is activated by invisible ultraviolet radiation—so-called black light—fluoresces or becomes a light emitter. Perhaps then this same window area that transmits the pleasant light of the sky might also furnish the lighting after dark.

If you hanker to sleep under a star-studded sky, bring stars indoors by painting them on the ceiling with fluorescent paint. Better still, repaper the ceiling with a prepared paper which has the entire galaxy of the Milky Way. This indoor sky is kept glowing come rain or snow by the invisible radiation of a near-ultraviolet, or black light, lamp.

This same fluorescent material can be used to change entirely the aspect of a room. It is possible to paint pictures or designs on the wallpaper, or print them into draperies and furniture upholstery with materials that ordinarily are invisible but when activated by black light glow brightly in various colors. Thus at the touch of a switch the appearance of a room may be changed completely.

What of phosphorescent materials—those mysterious chemicals that have the ability to absorb the free energy of daylight then reradiate it in the form of visible light after dark? Today they are relatively expensive and feeble light sources, but who is bold enough to state that they will always be so? The time undoubtedly will come when such light sources will, by balls of chemicals, absorb the free energy of daylight or sunlight and store it for our use at night, much as the electric storage battery stores energy to start our automobile engines.

Sunlight streaming through a window is pleasant to see and feel. We now have artificial sources that are capable of simulating sunlight. These may be projected to produce the appearance of sunlight streaming through the window, with the advantage that they can be controlled and made available anywhere at any time regardless of the actual state of the weather.

Our artificial sunlight also brings with it the erythemal rays contained in the outdoor sun and found to be so beneficial to health. The only real obstacle to reproducing sunlight effects indoors is cost, and costs are steadily coming down.

Adjacent in the spectrum to the vitamin-D-producing rays are the higher frequency germicidal rays — rays that effectively kill germs and air-borne bacteria. Today germs spread colds through an entire family. Or they close our schools with epidemics of mumps, measles, scarlet fever, etc. causing much discomfort, loss of time and involving us in high medical expenses. Tomorrow holds great promise of eliminating those conditions through the disinfection of indoor air by means of germicidal lamps. That is no fanciful dream! It has already been proven in hospitals, schools, military barracks, submarines, etc. It is only a step farther to carry it into our offices, factories, theaters, auditoriums, trains, busses, street cars, and our homes.

The germicidal lamps promise not only to cut down disease by freeing the air of germs, but also to save much food now spoiled by mold growth. Even though their principal output is not visible light, it is probable that eventually they will be incorporated in the lighting system.

We predict also that the lighting of tomorrow will combine visible light with health radiation so that we shall not need to have a separate sunlamp and waste time taking treatments.

What of infrared radiation for heating? It has always seemed to us unnecessary to heat 6,000 cu ft of air in a 20x30-ft room to make it comfortable for the occupants who never are in the upper third of the area; and to heat all that space 24 hr a day to make it comfortable for perhaps 3 or 4 hr occupancy. We believe the time will come when the various rooms of our homes will be equipped with infrared sources that will confine the area they cover to that used by the occupants, and the best sources of infrared energy take the form of lamps. On entering a room the flip of a switch will make this energy instantly available, and on leaving the same switch will instantly turn it off. No more furnaces to stoke, and no more space wasted with ugly radiators, coal bins, and other dirt-catching and producing heating apparatus.

Now let's step out of the house and use a little imagineering on the rest of the farm. Why should all of outdoors at night be a big black void except for relatively small areas adjacent to a yard light or a lantern? It seems to us that a great deal too much of the backbreaking labor on a farm is done in the middle of the day when the sun beats down and the thermometer registers 120 or 130 deg (in the sun). Then we go indoors at night when it is cool and comfortable and carry on such inactive things as reading, writing, sewing, etc. Let's reverse the process and do the heavy work at night when it is cool, and do the inactive jobs indoors out of the broiling sun during the daylight hours. Why don't we do that now? For just one reason—insufficient light! Is it too hard to visualize one or more high towers on the farm carrying such powerful light sources that the entire working area of the farm will

L. C. PORTER and G. F. PRIDEAUX are lighting engineers, Nela Park Engineering Division, General Electric Co.

be lighted to at least the levels of illumination we now use to work in the home or in the barn at night? We think not! Equipment to do that is already available (50,000-w lamps, for example). It is not nearly as difficult a problem as lighting a baseball field for night games. It is more comparable to lighting a football field, and even small high schools now are doing that. In attaining the goal of general outdoor lighting we shall probably pass through an intermediate stage of more localized lighting.

Some farm tasks could be performed as well at night with proper artificial light as in daytime and with much greater personal comfort. Other tasks, such as harvesting certain crops, will require that they be gathered at a certain time of the day in order to gain the maximum vitamin and sugar content—sometimes as much as 25 to 30 per cent more than if gathered at the wrong time of day. Time is a vital element in farming. The difference between a profit and a loss may often hinge on keeping at a task or keeping a machine going throughout the night. The farm of tomorrow may well have a jeep equipped with a small but powerful generator and a telescoping tower having several very powerful floodlights on top of it. Such a machine can quickly be driven under its own power to any desired location, say the vegetable garden, to furnish ample lighting for planting or harvesting the crops at night.

TRACTORS EQUIPPED WITH SUFFICIENT LIGHTING TO DO ALL DAYTIME OPERATIONS AT NIGHT

We believe that the time is here when tractors, for example, will be equipped with sufficient lighting to enable them to perform all of the present daytime functions effectively at night.

The Transactions of the American Society of Agricultural Engineers already contain records of the use of light to speed up plant growth. Some fall flowers are made to bloom in midsummer, or the blooming time of others is retarded a couple of months by simply supplementing daylight with relatively small amounts of artificial light. It is possible to grow plants entirely by artificial light independent of natural weather and light. In fact, it has been done—expensive today, but maybe not tomorrow.

Vegetable yields have been greatly increased by the use of artificial light—tomatoes, for example, 70 per cent. New types of plants have been developed by treating the seed with X rays, and germination time has been reduced by using infrared radiation. Black light is enabling the elimination of defective seed—ring rot in potatoes, for example—thus saving the loss of time and labor in planting unproductive seed.

With plenty of cheap light the farm of tomorrow can at least raise all of the vegetables and flowers for its own use in heat-insulated and artificially lighted greenhouses. In that manner any or all of the table vegetables can be made to ripen at any desired time. Fresh strawberries the year round!

Almost daily now we read in the papers of accurate bombing of specific targets through dense layers of cloud and fog, or at night. Does not that suggest how the range of man's vision has improved? With equipment rather akin to television it may tomorrow be possible to "see" throughout the barn from a bedroom "vision" panel, to determine the kind of intruder in the chicken house, to "see out" without windows, or to "see around" the premises at night with invisible rays.

Light beams have made good progress in industry for the automatic control of processes. They have not as yet been applied to farming. You ask where they could be? To automatic plowing, to seeding, to cultivating, mowing, grinding, feeding, watering—any number of jobs are susceptible to automatic control by means of the "seeing" electronic eye.

The use of artificial light in poultries is generally accepted practice. Add to this germicidal radiation to reduce mortality from air-borne diseases, sunlamps to increase egg production and to increase the nutritive value of the egg, then we'll be going places! Perhaps it won't be long before we have a single light source that emits all three of these vital wave-lengths — 2537 A (Angstrom units) for killing germs, 2967 A for health purposes, and visible light. Such lamps are already a research-laboratory possibility.

Experimently pig production has been increased 30 to 50 per cent by the use of lamps in baby pig brooders. The experiments of today often become the practice of tomorrow.

Experimentally considerable power has been transmitted through the air without wires. Is it out of reason to hope that the future holds broadcasting stations sending out power to be picked up and used anywhere as we now pick up the radio waves and turn them into sound and pictures?

Low cost of power is the answer to our problems. If and when we find out how to release the power of the atom we shall have available almost unlimited power. Progress has been made along those lines. Indications are that a teacup full of atomic fuel would be sufficient to drive our largest ocean liner to Europe, and on that basis probably an airplane could go to the moon! Who wants to go to the moon? We do, for there we may find vast deposits of wealth in the form of diamonds and precious minerals. Yes, we'd even like to go to Mars and find out how farming is done there!

Application of Stream Gaging to Small Streams and Ponds

(Continued from page 32)

streams which have a large proportion of spring-fed flow generally do have higher total yields. This is evident in the gaging-station records on streams west of Tired Creek where the average annual flow is almost double that of the streams east of Tired Creek.

Undoubtedly the runoff on many small drainage areas will be modified by conservation practices or by changes in the type of cover. This has been demonstrated beyond any question at numerous experimental stations. Thus the shape of the duration curve for surface runoff may require some modification for it to apply to drainage basins which differ considerably from the drainage basin above the index gaging station. It would be interesting to see how much modification of the duration curve is indicated by the results of controlled-runoff experiments.

To determine runoff as a result of all the contributing factors is a very complicated problem as any experimenter in hydrology will agree. If one were to start with rainfall and modify it by temperature, wind movement, evaporation, humidity, transpiration, absorption, transmissibility, and other factors to derive runoff, he would have an almost impossible task. Even if the influence of all these factors were evaluated under controlled conditions, the task would be difficult and expensive. The problem becomes much simpler, and the results much more likely to be reliable, if one can start with the actual measurement of runoff itself.

On looking ahead - from behind

On New Year's Day, 1935, farmers around Kaneville, Illinois, were talking about the "new" tractor on Clarence Dauberman's place. It wasn't really new—in fact, it was a nine-year-old Farmall. But it was different.

Designed to burn heavy fuels, the tractor had been converted into a "high compression job." What was that? Well, the engineers had put in "high altitude" pistons to increase the compression pressure in the cylinders. That's why they called it "high compression." And why did they do that? To give Dauberman's tractor more power with regular gasoline. The experiment was successful.

By New Year's Day, 1936, high compression tractors designed to get the full power of good gasoline were a reality. During 1935, Oliver had brought out the Oliver Row Crop 70, designed for most efficient operation on the regular grade of gasoline being made at that time. Other makes and models soon followed.

Would *good* gasoline really pay in a tractor? Would farmers want this "quality" development in tractor engines? Those were questions being asked by many.

Those questions have been answered. The unquestioned popularity of high compression tractors today has proved that farmers do want the advantages of good gasoline in their tractors as well as in cars and trucks.

Today, the major trend in tractor engine design and production is toward high compression tractors. Their production now exceeds all other types.

Here at Ethyl we've had an opportunity to work with manufacturers in this pioneering of high compression tractor engines to give farmers the full benefits of gasoline.

But as we stop to review the progress that has been made, we are keenly aware that neither the standards of gasoline quality nor of farm power stand still. Our challenge continues to lie in the development of still better farm power from still better gasoline.

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Hydrology Committee Activities

IN THE following paragraphs the chairman of the A.S.A.E. Committee on Agricultural Hydrology—D. B. Krimgold, soil conservationist, Soil Conservation Service, USDA—outlines the scope of the Committee's activities and its objectives and presents a plan for expanding its organization:

"That the Committee on Agricultural Hydrology has been in existence in the American Society of Agricultural Engineers for at least nine years indicates that the Society has long realized the importance of water in agricultural production and in the management of the most basic of all resources—the soil. The work done during the last decade has greatly advanced our knowledge and thinking regarding the role of water in agriculture. Agricultural engineers and scientists alike are of late becoming increasingly aware of the many applications of hydrology in agriculture. The Committee on Agricultural Hydrology may, therefore, be in a better position than ever before to render valuable service to agriculture.

"Engineering has been defined as the branch of science concerned with utilizing the laws and forces of nature and the properties of matter in the service of man. If we add the words 'in agriculture', we have a definition of 'agricultural engineering'. Within this framework, agricultural hydrology can be defined as the branch of science which treats of the distribution, occurrence, action, and movement of water on the earth's surface, in the soil, and in the atmosphere, in so far as they relate to agriculture.

"This definition must be clarified and qualified somewhat before it will accurately express the scope of the activities of the Committee on agricultural Hydrology. The reference to movement of water' on the earth's surface could imply that agricultural hydrology is concerned with the flow of water in open channels and other phases of what is generally recognized as the field of hydraulics. Strictly speaking, this implication may be correct. For the purpose of the Committee, however, it is neither necessary nor desirable to combine these two distinct fields. Subjects such as hydraulic characteristics of open channels and of spillways are definitely in the field of hydraulics, and should not be the concern of the Committee, except in so far as they may directly affect rates of runoff or other phases of agricultural hydrology.

"Another necessary clarification is that, while evapotranspiration and other phases of water-plant-soil relationships are not specifically mentioned, they are certainly within the field of agricultural hydrology and therefore within the scope of the Committee. Evapotranspiration is not only the paramount factor in irrigation requirements but also largely determines amounts of surface and subsurface runoff and of ground water and water-table levels. The phrase 'in so far as they relate to agriculture' means for instance that in agricultural hydrology we are concerned with overflow and inundations of agricultural land and with effects of land use on floods, but not with storm sewers of cities and with flood control on rivers involving large dams, extensive levees and similar control measures. Within this scope the objectives of the Committee can be briefly stated as follows:

1 To promote the use of hydrologic principles and facts in agriculture

2 To foster research in the field of agricultural hydrology

3 To aid agricultural engineers and others in performing professional work involving various phases of agricultural hydrology.

"The means available to the Committee in attaining these objectives include (a) determination of deficiencies and shortcomings of basic scientific knowledge and facts needed in the effective application of agricultural hydrology, (b) calling attention of appropriate public and private agencies to the need for specific types of information and for appropriate lines of research, (c) making available to agricultural engineers and others the latest information in the field of agricultural hydrology, (d) through technical publication and meetings serving as a forum from which new ideas and findings can be presented and discussed, and (e) promoting and encouraging close collaboration with technical and professional groups, particularly in agriculture, both in the United States and abroad.

"The membership of the American Society of Agricultural Engineers includes engineers and technicians whose major work and interest lie in the application of known scientific facts and principles, and men engaged in research, that is, in discovering and developing such facts and principles. The Committee on Agricultural Hydrology needs therefore to be organized so as to serve the requirements of both application and research.

"Agricultural hydrology finds application in several phases of agricultural engineering, namely, drainage and flood control, irrigation, farm water supply, erosion control, and water conservation. Precipitation, runoff, evaporation from water surfaces, ground water, and erosion and sedimentation must in one way or another be dealt with in all the aforementioned phases of agricultural engineering. Water-plant-soil relationships which, in addition to these factors, involve also water properties of soils and transpiration, enter directly or indirectly into every application and into all research in the field of agricultural hydrology.

"If precipitation were treated only from the standpoint of erosion control, the results might not be directly applicable in land drainage or in water supply. The same is true with respect to runoff. Rates of runoff are all that may be necessary in the design of erosion-control structures while amounts of runoff are equally, if not more, important in drainage, water supply, irrigation, and water conservation. In the past evapotranspiration (consumptive use) was considered solely in connection with irrigation in arid regions; consequently what information is now available is of only limited value in other phases of agricultural engineering. These and many other examples which could be cited suggest that with proper coordination the Committee could work most effectively if it consisted of standing subcommittees on each of the major hydrologic factors and one on the all important subject of water-soil-plant relationships. Special subcommittees, such as one on instrumentation in hydraulic research, or on definitions, units, accuracy of measurements, etc., may be added as ned for them arises and terminated or suspended when their task is completed.

"The effectiveness of each of the subcommittees will depend largely on the extent to which their work is coordinated with that of other groups in the Society concerned with various phases of agricultural hydrology. This coordination can be best accomplished by discussions and exchange of ideas with the chairmen or representatives of the A.S.A.E. Soil and Water Division and its committees on drainage, irrigation, ponds and reservoirs, and soil erosion. The following is the reorganization plan for the Committee now being put into effect:

COMMITTEE ON AGRICULTURAL HYDROLOGY

(Coordinating group: Chairman of the Committee, chairmen of subcommittees, chairman of Soil and Water Division, and chairmen of Committees on Irrigation, Drainage, Erosion Control, and Ponds and Reservoirs)

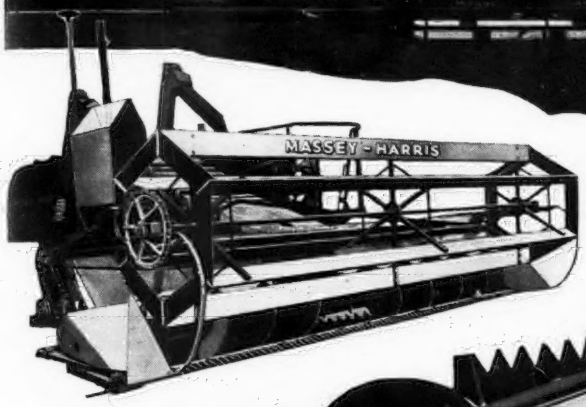
Subcommittee on Precipitation
Subcommittee on Runoff
Subcommittee on Ground Water
Subcommittee on Erosion and Sedimentation
Subcommittee on Evaporation from Water Surfaces
Subcommittee on Water-Plant-Soil Relationships
(Other subcommittees as needed)

"Each of the subcommittees will, within their more limited scope, have the same general objectives and will endeavor to achieve them through the means outlined for the Committee as a whole. The Subcommittee on Precipitation, for instance, may undertake to determine the types of information on precipitation required in various phases of agricultural engineering. It may find that 'mean annual' and 'mean monthly' values of precipitation commonly reported are of only limited value. The Subcommittee may wish to recommend that the various agencies engaged in publishing pricipitation data should make available 'modal' values of monthly, annual, and seasonal precipitation or values which were equalled or exceeded 75, 80 or 90 per cent of the time during the period of record. It may sponsor a symposium or round table on the subject of relation of rainfall intensities and of drop sizes to erosion, infiltration, runoff, moisture available for plants, and ground-water recharge. The result of such a symposium may be a recommendation that the published records of precipitation should include amounts of rain falling at various intensities during various periods of the year or of the growing season.

"One of the perplexing problems in determining rates of runoff for the design of conservation and other structures on small watersheds is how to apply the results from small agricultural watersheds to larger areas. The limited information now available in most regions is for areas ranging from a few acres to two or three square miles or for areas of about 50 square miles or more. This case is an example of the many problems which the Subcommittee on Runoff may tackle. The subjects of potential and actual evapotranspiration, of soil moisture, irrigation requirements, and others—would be the concern of the Subcommittee on Water-Plant-Soil Relationship. The Subcommittee on Evaporation from Water Surfaces could perform a great service to agriculture by examining existing information in the light of specific needs in connection with hydrologic design of ponds and reservoirs, and similar problems. Many other examples could be cited.

"However, detailed plans for the technical work of each of the subcommittees will be developed by the respective chairmen in collarboration with other members of the coordinating group. Sponsoring and organizing symposiums and round tables already referred to, selecting the best papers on their subject for abstracting and inclusion in the annual report or publication of the Committee, encouraging the trans *(Continued on page 42)*

Massey-Harris Self-propelled Combines operating as a team, helping garner unusually heavy crops of the 1945 season.



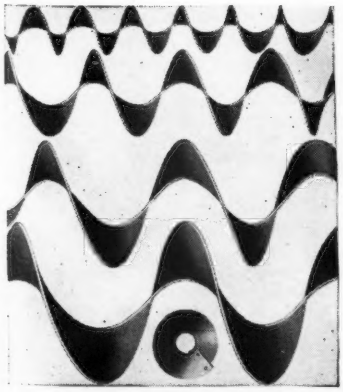
Note the screw conveyor-beater unit extending the full width of the machine, just back of the sickle bar.

Special 18" diameter screw conveyor unit made by Link-Belt for Massey-Harris Combine. This unit is rotated on two bearings, one at each end.

LINK-BELT

Screw Conveyor

SIMPLIFIES DESIGN—IMPROVES OPERATION



Left: These views are typical of the wide variety in diameters, pitches and gauges of screw conveyor, in both continuous-flight and sectional-flight types as manufactured by Link-Belt for incorporating in agricultural implements.

Growing recognition of the advantages of screw conveyor on harvesting equipment is typified by this recent model Combine built by Massey-Harris. The simple one-piece element, with only two bearings, replaces the platform conveyors, cross conveyor and beater of earlier models.

Smaller diameter screw conveyors under the sieves, carrying the threshed grain to the elevators, utilize Link-Belt Helicoid screw conveyor flighting. Simple, compact, efficient, positive, adaptable, screw conveyors are uniquely suited to agricultural implement purposes. As originator and largest manufacturer of Helicoid (continuous rolled flight) and sectional flight screw conveyor, Link-Belt is your preferred source. Our unmatched facilities enable us to meet any requirements from 2" and larger diameter, in desired pitch and gauge, mounted on solid shafts, hollow shafts or unmounted.

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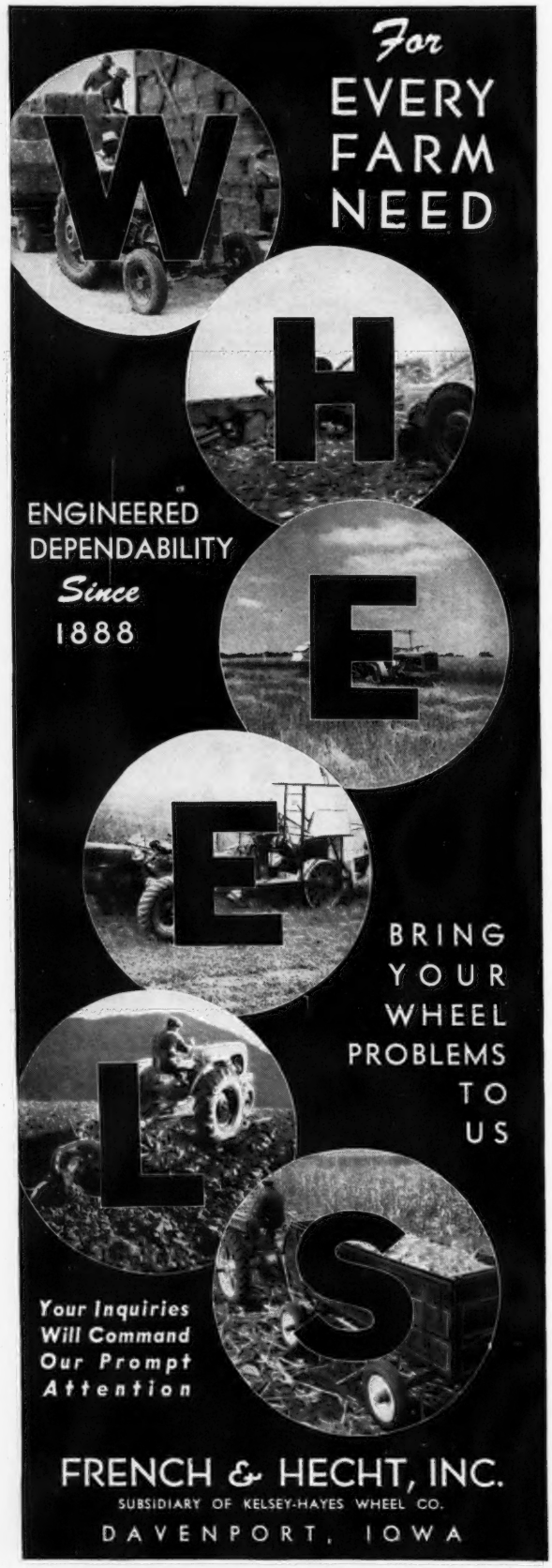
LINK-BELT SCREW CONVEYOR

COLLARS · COUPLINGS · HANGERS · TROUGHS · BOX ENDS · FLANGES · THRUSTS · DRIVES



NEWS SECTION

A.S.A.E. Meetings Calendar

February 13 and 14 — SOUTHEAST SECTION, Thomas Jefferson Hotel, Birmingham, Ala.

February 26—PACIFIC COAST SECTION, Sacramento, Calif.

June 24 to 27—ANNUAL MEETING, New Jefferson Hotel, St. Louis, Mo.

December 16 to 18 — FALL MEETING, Stevens Hotel, Chicago, Ill.

Pacific Coast Section Meeting

SACRAMENTO, Calif., has been designated as the place of the 24th yearly meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, to be held February 26. This meeting is to be followed on February 27 by a meeting of the Hydrology Section, Pacific Southwest Division, American Geophysical Union, and on February 28 by the Western Snow Survey Conference, providing a coordinated three-day program.

Southeast Section Meeting Program

SEVERAL new subjects and new approaches to old problems are featured in the program for the yearly meeting of the Southeast Section of the American Society of Agricultural Engineers, to be held at the Thomas Jefferson Hotel, Birmingham, Ala., February 13 and 14.

Wm. E. Meek, Section chairman, will open the first session at 9:00 a. m. on February 13. Papers scheduled on the tentative program provided by G. E. Henderson, secretary of the Section, include "Research Problems in the South Today," by R. H. Driftmier, University of Georgia; a talk by A. W. Turner, assistant chief, BPISAE, USDA; "Raindrops and Soil Erosion," (illustrated) by W. D. Ellison, SCS, USDA; "Fiber Production in Cuba," (illustrated) by Jose Garcia Inerarity, Argo-Pecuario, Havana, and "The Force Account Method of drainage in Washington County, Miss.," by R. H. Pedigo, chief engineer, county board of commissioners.

Farm building topics are dominant in the afternoon program, with Hugh R. Roberts, Section vice-chairman, presiding. Items scheduled include "The Farm Building and Structures Problem in the Southeast," by C. E. Seitz, Virginia Polytechnic Institute, with discussion by D. N. Bottoms, Alabama Polytechnic Institute, and H. R. Roberts, Portland Cement Assn.; "Availability of Building Material for Farm Structures," by E. M. Garner, Carolina Lumber and Building Supply Assn.; "How Obstacles to Modern Plumbing Have Been Removed for the Farmer," by R. Lundquist, Sears, Roebuck & Co., and "The REA Rural Plumbing Program," by Earl L. Arnold, plumbing unit, REA, USDA.

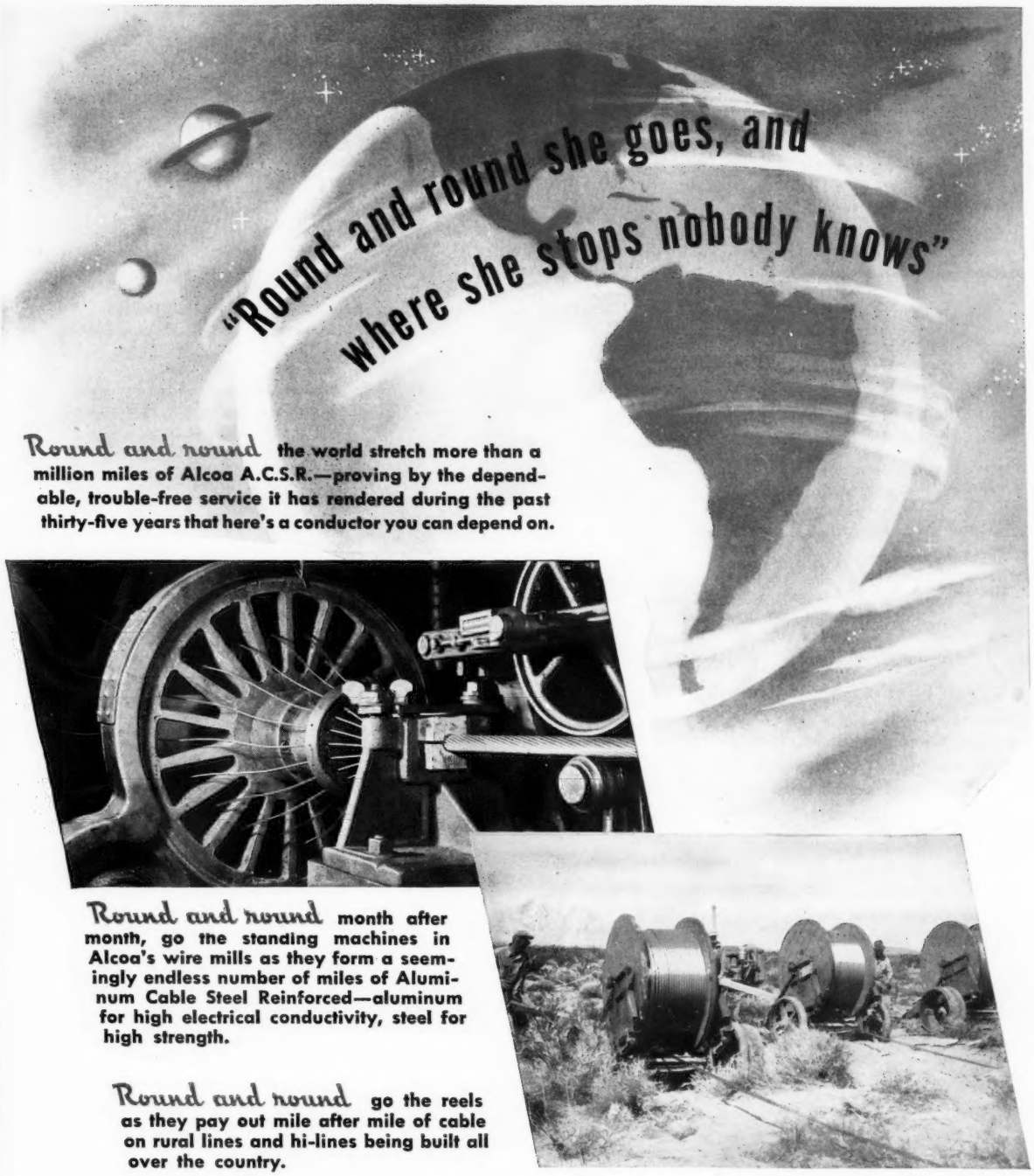
The Section dinner will be held at 6:00 p.m., Wednesday.

Concurrent sessions on farm machinery, soil conservation, and rural electrification are scheduled for Thursday forenoon, February 14.

In the machinery session with Mr. Meek presiding, subjects and speakers are to include "Present Machines in Mechanized Cotton Production," (illustrated) by T. L. Bagette, Delta (Miss.) Experiment Station; "The Jeep in Agriculture," by T. N. Jones, Mississippi Agricultural Experiment Station; "Design of Farm Shop, Machine and Storage Buildings," by J. D. Neilson, Mississippi Agricultural Extension Service; and "Current and Future Machines for Soil Conservation Farming," by Wm. E. Meek, International Harvester Co.

Soil conservation program features listed are "Drainage and Land Use Problems in the Southeastern Region," by A. Carnes, SCS, USDA; "Foundation Failures of Floodways and Spillways," by S. R. Sapirie, SCS, USDA; "Stream Bank Erosion," by H. H. Lester, SCS, USDA; "Groundwater for Agricultural Irrigation in Georgia," by S. M. Herrick, U. S. Geological Survey; "Terrace Maintenance," by J. T. McAlister, SCS, USDA; and "Proper Cropping Practices Strengthen Terraces on Sloping Crop Land," by John R. Carreker, SCS, USDA. Russel Woodburn, vice-chairman of the Southeast Section, will preside at this session.

The rural electrification program offers "Wiring Program of Alabama Power Company," by Mr. Mauldin, Alabama Power Company; "Some New Developments in Farm Motors and Controls," B. P. Hess, Westinghouse Electric Corp.; "Outline for a Rural Electrification Text," U. F. Earp, Virginia Polytechnic Institute; "REA Utilization Program," by *(Continued on page 40)*



Round and round the world stretch more than a million miles of Alcoa A.C.S.R.—proving by the dependable, trouble-free service it has rendered during the past thirty-five years that here's a conductor you can depend on.

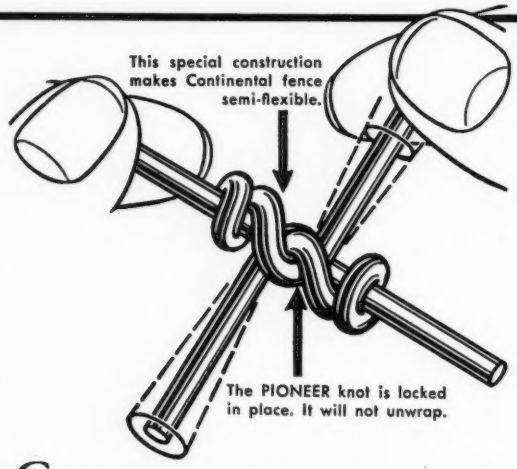
Round and round month after month, go the standing machines in Alcoa's wire mills as they form a seemingly endless number of miles of Aluminum Cable Steel Reinforced—aluminum for high electrical conductivity, steel for high strength.

Round and round go the reels as they pay out mile after mile of cable on rural lines and hi-lines being built all over the country.

For help on engineering your lines, consult Alcoa, makers of Alcoa A.C.S.R. and fittings. ALUMINUM COMPANY OF AMERICA, 1976 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA A-C-S-R
ALUMINUM CABLE STEEL REINFORCED

ALL FENCE IS NOT ALIKE


This special construction makes Continental fence semi-flexible.
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CONTINENTAL fence is different! It's the only fence with the PIONEER KNOT. This knot makes Continental fence semi-flexible to better withstand the crowding of livestock without hinging, folding or buckling of the stay wires. It gives extra strength to absorb shock and keep standing straight. New Continental fence is made of copper steel wire and has a uniform zinc coating. The Continental dealer near you can now supply essential needs of fence, barbed wire, nails and other steel products.

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NEWS SECTION

(Continued from page 38)

J. R. Cobb, REA, USDA, with discussions by D. E. Washburn, TVA, and a wiring movie.

Joining in a combined final session in the afternoon, the southeastern agricultural engineers will hear "Progress in Integrating Agricultural Engineering into Vocational Agriculture in the Southeast," by A. P. Fatheree, state supervisor of agricultural education for Mississippi; "Financing Water Management and Soil Improvement Plans on the Individual Farm," by Darryl R. Francis, Federal Reserve Bank of St. Louis; and "From the Secretary's Scrapbook," Raymond Olney, secretary, A.S.A.E.

Following the foregoing program, the meeting will end with a short business session of the Section.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Norman B. Akesson, civil service physicist, degaussing activities, U. S. Navy. (Mail) Kitsap, Wash.

Murrel L. Bailey, associate professor of agricultural engineering, Michigan State College, East Lansing, Mich.

Don A. Beckenbaugh, assistant works manager, J. I. Case Co. (Mail) Rockford, Ill.

Robert L. Erwin, research in soils, Ohio State University. (Mail) 263 Rockland St., Portsmouth, N. H.

Marvin T. Geddings, agricultural engineer, Duke Power Company, Spartanburg, S. C.

Alton R. Grout, district engineer, N. Y. State College of Agriculture. (Mail) 26 Orville St., Glens Falls, N. Y.

Dan N. Harrell, R. R. No. 2, Tifton, Ga.

George R. Harrington, chief engineer, Blood Bros. Machinery Co., 122 S. Michigan Ave., Chicago, Ill.

John W. Heck, Jr., sales promotion manager, Certain-teed Products Corp., 120 So. LaSalle St., Chicago, Ill.

Eladio Aranda Heredia, profesor de la Escuela Especial de Ingenieros Agronomos, La Moncloa, Madrid (8) Spain.

Walter L. Hewes, Jr., farm equipment specialist, General Electric Supply Corp., 429 N. 7th St., Philadelphia, Pa.

Ronald A. Loveland, U. S. Navy. (Mail) USS Crevalle (SS291), c/o Fleet Postmaster, New York, N. Y.

Robert R. McBeth, head, agricultural engineering department, Louden Machinery Co., Fairfield, Iowa.

William R. Moore, agricultural engineer, Soil Conservation Service, USDA. (Mail) 342 West Patriot St., Somerset, Pa.

Kurt Nathan, student, Cornell University. (Mail) 7 Annette Ave., Binghamton, New York.

Robert W. Nordlie, senior design engineer, Goodyear Aircraft Corp. (Mail) Y. M. C. A. Akron 8, Ohio.

Fenner H. Peckham, farm service engineer, Lowell Electric Light Corp., 29 Market St., Lowell, Mass.

Joseph D. Rankin, farm production equipment specialist, General Electric Supply Corp., 680 Antoinette St., Detroit 2, Mich.

Comer J. Renfroe, manager, rural division, South Carolina Power Company, 141 Meeting St., Charleston, S. C.

LeRoy Shirley, junior conservationist - planning technician, Soil Conservation Service, USDA. (Mail) R. R. No. 5, Anderson, S. C.

Lorin E. Smith, assistant agricultural engineer, sugar beet investigations, U. S. Department of Agriculture. (Mail) Box 465, East Lansing, Mich.

Wendell W. Unfer, Editor, farm mechanics dept., "Prairie Farmer". (Mail) R. R. No. 1, Box 175, Des Plaines, Ill.

I. Warren Webster, branch manager, Starline, Inc., 51 Maplewood, Albany, N. Y.

TRANSFER OF GRADE

John L. Burgan, director of rural development, New York State Electric & Gas Corp., 108 East Green St., Ithaca, N. Y. (Associate to Member)

Richard K. Frevert, assistant professor of agricultural engineering, Iowa State College, Ames, Iowa (Junior Member to Member)

Carl E. Guelle, assistant manager, tillage and seeding machine sales dept., International Harvester Co., 180 N. Michigan Ave., Chicago, Ill. (Associate to Member)

"First time I've ever had a barn that's just right,"

SAID TOM LAPHAM

"It'll save you a lot of work"

SAID THE COUNTY AGENT

The barn Tom Lapham had been using all along was built by his grandfather, back in the days when they used to have real barn raisings around the countryside.

It had been added to, of course—a shed at the end and an ell to the south for the young stock and more haymow. And, by rearranging things inside from time to time, Tom did his best to help his grandfather's barn keep up with the changes in his farming methods.

But last summer he finally gave up as a bad job the business of trying to find more room in the old barn. He decided to build a new one as soon as haying was done.

Next time he was in town, Tom dropped in at the County Agricultural Agent's and told him about his plans.

"This time, I'd like to have a barn that really suits the way I'm farming," Tom told the County Agent.

"Well, let's take a look at some barn plans that the farm-engineering folks over at State College have been cooking up. They've got some pretty good ideas in them."

They thumbed through the farm-building plans book that the County Agent had. And Tom found a couple of plans that he liked. That afternoon, the County Agent went with Tom out to the Lapham place to look over the site for the new barn.

After talking with the County Agent about location and interior arrangement until almost choretime, Tom had a good idea about what kind of a barn he wanted, to save him work in handling feed and taking care of his stock. The County Agent ordered the plans that night.

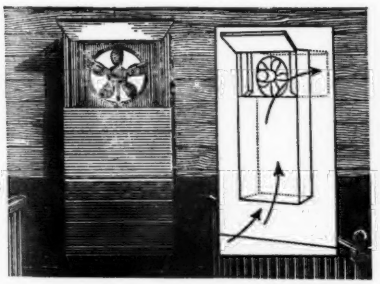
Tom had to make some changes in the plans, of course, and a few more changes as the new barn went up. From the time the foundation was started until Tom moved his stock in last month, he's had lots of helpful barn-building advice from his County Agent.

"It's a fine thing to have a barn that's built right," the County Agent said the last time he dropped around.

"And the County Agent's a fine hand to have at a barn raising," Tom Lapham replied.

All over the country, farmers are getting help from their County Agents that makes farming *better and easier.*

Another thing that good farmers are doing to farm better and easier is to make full use of electricity.



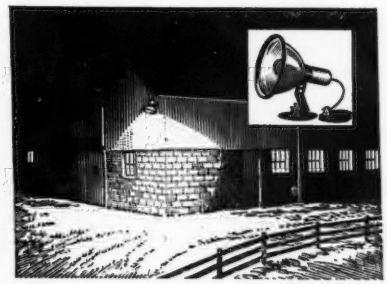
GIVE YOUR BARN A BREATH OF FRESH AIR!

Electric barn ventilation pays off 3 ways:

1. Controlled ventilation of your barn reduces repair bills by keeping it dry. Walls don't sweat and drip; timbers don't rot.
2. Barn ventilation protects the health of your animals, helps maintain their milk production. Disease germs thrive under damp, humid conditions.
3. With controlled fresh air, your barn becomes a more comfortable, more healthful place in which to work.

Ask your dealer or power supplier to help you plan your electric barn-ventilating system. An electric system is simple to install, easy to control. It is less than half as expensive as a cupola system.

And be sure to look for the G-E motor on the fan. G. E. works directly with machinery manufacturers to determine the best size and type of motor for each farm application.



PROTECT YOUR FARM WITH FLOODLIGHTS

Floodlighting yards and work areas protects against thievery and accidents, lets you work after dark.

G. E.'s Handy-Midget floodlight is weatherproof, inexpensive, and lightweight. Fasten it to the side of any building or use it wherever you need extra light. Easy to install, the circular-steel base will hold it firmly in any position. Comes with six feet of rubber cord. Steel parts have durable finish.

Your nearest G-E dealer has the Handy-Midget floodlight in stock. Let him show you where it can help you farm more safely and efficiently.

The Modern Farm Is an Electric Farm!

Electricity on the farm can make life more pleasant and work easier.

If you don't have electricity, get in touch with the electric service supplier in your area.

If you already have electricity, get your full value out of it by making it do more jobs for you.

To help build up modern farms electrically continues to be the full-time job of a staff of farm specialists in the G-E Farm Industry Division.

MORE POWER TO THE AMERICAN FARMER

GENERAL ELECTRIC

669-23-155-8709

Ralph Palmer Returns to A.S.A.E. Staff

RALPH A. Palmer returned January 7 to his position as assistant secretary of the American Society of Agricultural Engineers, after four and one-half years of duty with the Army Air Forces. A reserve officer since 1926, he was ordered to active duty in July, 1941, as a Captain, Air Corps, and stationed at the Air Corps Radio School, Scott Field, Ill.

In February, 1942, he was transferred to Morrison Field, Fla., as one of the administrative cadre for the new Air Corps Radar School, and moved with it in May to its new field at Boca Raton Fla., where he served for various periods as station administrative inspector and as base plans and training officer. He was promoted to Major, AUS, in February, 1942. In September, 1943, he was transferred to the Air Service Command at the Middletown (Pa.) Air Depot, from which he was placed on overseas duty in England. There he was located at Base Air Depot No. 1, Warrington, England, and for two years was continuously in command of 1200 to 2500 men in administrative areas within the station. On his return to the United States he was promoted to Lieutenant Colonel, Air Corps Reserve, and placed on terminal leave December 20, 1945.

Hydrology Committee Activities

(Continued from page 36)

lation and publication of papers and reports by foreign workers in the several phases of agricultural hydrology, and establishing relations with similar groups in the United States and abroad are some of the other functions of the subcommittees. The runoff committee of the American Geophysical Union, for instance, may be asked to establish liaison with the A.S.A.E. Subcommittee on Runoff. The same may be done with the other committees of the A.G.U., the soil physics and soil technology section of the Soil Science Society of America, and with similar groups of other scientific and technical societies, such as the National Highway Research Board, the American Society of Civil Engineers, etc. Special subcommittees will be set up when need for them arises and their functions will be outlined by the coordinating body.

"The cooperation of non-members as well as members of the Society whose interests lie in the field of agricultural hydrology is invited in connection with the work of the Committee."

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request.

POSITIONS OPEN

DESIGN ENGINEERS (12) for combines, corn pickers, hay balers and tractors. Midwest farm machinery manufacturer. Salary, $250 to $325 a month. O-401

LABORATORY TECHNICIAN for chemical analysis of feeds, etc. Midwest farm supply company. Salary open. O-412

EXTENSION AGRICULTURAL ENGINEER to specialize in farm buildings. Southern state college. Salary open. O-430

RURAL ELECTRIFICATION SPECIALIST for teaching and research. Southern state college. Salary open. O-434

SALES ENGINEER to contact and assist design engineers of farm machinery in design of power transmissions. New England power transmission manufacturer. Salary open. O-448

ASSISTANT EXTENSION AGRICULTURAL ENGINEER as full-time specialist in safety and farm buildings work. Eastern state college. Salary, $3000 or more. O-449

ASSISTANT OR ASSOCIATE AGRICULTURAL ENGINEER for research and teaching in irrigation, soil erosion, and land development work. Western state college. Salary, $3000 to $3600. O-452

IRRIGATION ENGINEER for experimental work on use of water in irrigation, etc. Midwest state college. Salary, $3400 or more. O-456

DISTRICT MANAGER to make recommendations for and sell electric fly-screen installations in central New York state. Eastern manufacturer. Salary, $3000 to start. O-458

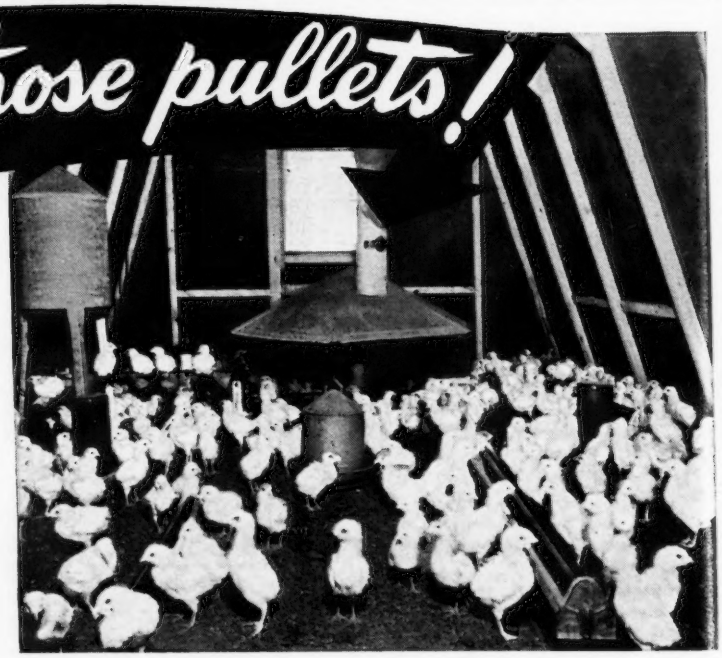
DESIGNERS, class A (3), for design of grain, corn, hay, and silage harvesting machinery. Midwest farm machinery manufacturer. Salary, $275 per month (min). O-459

DESIGNERS, class B (3), for layout work on grain, hay, and silage harvesting machinery. Midwest farm machinery manufacturer. Salary, $235 per month minimum. O-460

AGRICULTURAL ENGINEER (assistant professor rank) for teaching and research work in all branches of agricultural engineering, Eastern state college. Salary, $2800 per year. O-461

(Continued on page 44)

Protect those pullets!



Proper housing pays! Farm structures made with Masonite* Tempered Presdwood bring big returns in better poultry health, increased yield, lower mortality.

Presdwood is strong, dense and hard. It's highly resistant to moisture. At the same time, it's comparatively light in weight. Portable structures made of this rigid, grainless material are easily transported to new ground. They have a minimum number of joints and crevices—making them easier to clean—encouraging good sanitation. The absence of drafty cracks promotes vigorous health, discourages disease and pests.

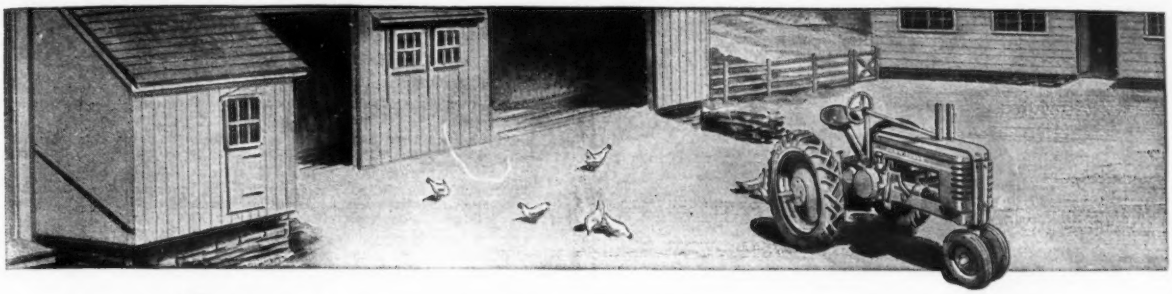
Many farm structures using Presdwood can be assembled in sections. For more information about Presdwood and its variety of farm uses, address Masonite Corporation, Dept. AE-1, 111 W. Washington St., Chicago 2, Illinois.

MASONITE BRAND PRODUCTS

REG. U. S. PAT. OFF.

Products of the State of Mississippi

*"Masonite" is a trade-mark registered in the U. S. Pat. Off. and signifies that Masonite Corporation is the source of the product.



"She's still yours, son"

"It was quite a few years ago, son, when you plowed your last field with our John Deere tractor. She had already put in plenty of good licks. But that was just the beginning.

"I've been pushing her plenty since you left . . . day in and day out, from early spring to late fall. But she can take it.

"She's still yours, son. You can step in right where you left off. She'll help us keep things rolling. And before long we'll be able to get still more time-saving and labor-saving equipment. Then we can farm more land . . . raise bigger, more profitable crops."

★ ★ ★

John Deere Tractors and other John Deere Farm Equipment have been doing extra duty during these wartime years.

They have helped American farmers accomplish more with less help. They have packed results into every working hour . . . proving the soundness of John Deere's policy of putting only high quality materials and workmanship into John Deere products.

Backing up the quality in John Deere equipment has been the excellent repair and overhaul service provided by John Deere dealers.

Quality equipment and quality service have stood shoulder to shoulder and met every test of the greatest food production program of all time.

JOHN DEERE

MOLINE, ILLINOIS

SINCE 1837

JOHN DEERE

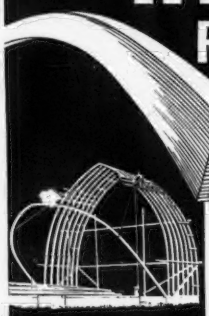
QUALITY FARM EQUIPMENT

Farming on the Contour with
REGULAR EQUIPMENT

Regular farm equipment does an excellent job of contour farming. Because it has the advantage of highly automatic control, modern farm equipment is ideally suited for soil conserving operations. The soil is everyone's concern. That's why the farm equipment industry is leading the way in the vital campaign for soil conservation—a campaign to safeguard our future.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago 1, Illinois

RILCO *Laminated Wood*
RAFTER ARCHES



READY TO ERECT . . . . NO MEASURING, CUTTING OR FITTING . . . .

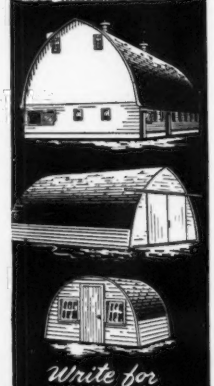
Rilco Rafters are delivered to the farm ready for erection, accurate as to dimension, end trimmed and drilled. They can be erected in less time than any other type of framing. The erection is accurate, because all measuring, cutting and fitting has been done at the factory.

This is a tremendous value to farmers. It assures sound construction. As the foundation is being poured, sill anchor bolts are placed 6 feet on centers. Holes for these bolts are a simple matter to drill in the sill. So also are the holes for the Rilco angle irons which anchor the rafters to the sill.

Simple, clear directions for erecting the rafters accompany each shipment. These directions cover two types of framing — horizontal drop siding—vertical car siding.

After sill is in place, the rafters are joined at the ridge with metal ridge plates, then raised as a single arch and bolted to angle irons at sills. Rilco Rafters not only assure better construction but save time and labor in erection. The side wall and roof framing of a Rilco 34x60 barn has been erected by five men in 5 or 6 hours. every type of farm building together with

The Rilco Catalog illustrating rafters for engineering data will be sent on request.



Write for **FREE BOOK**

RILCO LAMINATED PRODUCTS, INC.
A Weyerhaeuser Institution
1591AE First National Bank Bldg., Saint Paul 1, Minn.

PERSONNEL SERVICE BULLETIN

(Continued from page 42)

AGRICULTURAL ENGINEER for drafting, design, and development work on farm machinery. Eastern farm equipment manufacturer. Salary open. O-462

RESEARCH SCHOLARSHIP in connection with dairy barn research project. Midwest state college. Salary, $1400, with opportunity to carry up to 5 credits of college work. O-464

PROMOTION DIRECTOR to supervise and plan structures activities in farm and industrial fields. Location Chicago or New York. Some travel. Eastern trade association. Salary, $6000 to $7000. O-465

JUNIOR PROMOTION MAN (on farm structures) to prepare publicity, advertising, etc., and to work with colleges, 4-H clubs, etc., at Midwest location. Considerable travel. Eastern trade association. Salary, $3500. O-466

AGRICULTURAL ENGINEER to develop and design pumps and other farm implements. Western New York farm machinery manufacturer. O-469

RESEARCH FELLOWS (3) in agricultural engineering with opportunity to carry full-time graduate study leading to master's degree. Midwest experiment station. Salary, $540 for 9 months. O-470

COPYWRITERS (2) for tractors and tractor-mounted and tractor driven implements and machines. Midwest farm machinery manufacturer. Salary $150 to $325 per month. O-471

FARM STRUCTURES ENGINEER to carry on extension work looking to improvement of farm housing and rural sanitation and to assist in design of concrete structures. Midwest trade association. Salary commensurate with experience and ability. O-472

SALES PROMOTION ENGINEER (writer) to collect material and then edit magazine for rural builders and farm leaders, as well as prepare other promotion literature. Midwest trade association. Salary commensurate with experience and ability. O-473

ENGINEER to design corn planters, grain drills, manure spreaders, harrows, and other farm implements to gradually replace present chief engineer approaching retirement. Midwest farm mach mfr. Salary open. O-474

TWO JUNIOR ENGINEERS to work on detail design of spray machinery including assistance in redesigning high-pressure pumps, guns, tanks, vehicles, and practically an entire new line of products. Midwest farm mach. Salary $2500 at start. O-475

ASSOCIATE EDITOR to write stories and do other editorial work on rural electrification trade publication. Eastern publisher. Salary $200 to $250 per mo. O-476

AGRICULTURAL ENGINEER to take responsible position with a large farm management organization serving 50 farms and other rural industries in Ohio, to handle problems in farm mach, farm structures, rural electrn, soil and water conservn, and farm work simplification. Salary $3000 to $5000. O-477

FARM STRUCTURES SPECIALIST for design, drafting, and development of plans and specifications for farm residences and other structures, and for offices on branch agricultural experiment stations. Midwest state college. Salary $3000. 0-478

AGRICULTURAL ENGINEER for design and development of corn pickers. Midwest farm mach. mfr. Salary open. 0-479

ENGINEERS for conservation work with U. S. Soil Conservation Service. Entrance salaries, $2320 (P-1) and $2980 (P-2). (A.S.A.E will refer interested persons to appropriate SCS regional offices on request.)

POSITIONS WANTED

SALES ENGINEER desires sales and/or eng work in southwest U.S. on salary or commission basis. Ten years' wholesale farm tractor and mach sales, collection and service experience. Age 42. W-204

AGRICULTURAL ENGINEER (B.S. degrees in both ag and ag-eng.) desires teaching, extension or research work in power and machinery. Age 39. W-213

AGRICULTURAL ENGINEER (B.S. degree) desires sales or sales engineering and service or design and development work in farm structures field. Age 35. War veteran. Salary, $5000. W-219

AGRICULTURAL ENGINEER (B. S. degree) desires development, research or sales work in power and machinery or rural electrification field. Age 24. War veteran. W-221

AGRICULTURAL ENGINEER (B.S. degree) desires design and development or sales engineering and service work in farm structures field. Age 26. War veteran. W-224

AGRICULTURAL ENGINEER (B.S. degree) desires teaching and extension or research work in rural electrification or farm structures with public service agency. Age 27. Salary, $225 to $325 per month. W-226

AGRICULTURAL ENGINEER (B.S. degree in both Ag. and M.E.) desires design and development work in farm machinery field. Age 28. Salary, $350 per month minimum. W-227

AGRICULTURAL ENGINEER (B.S. degree) desires design and development or research work in farm structures or soil and water field, either private industry or public service. Age 35. Salary, $5000. W-230

AGRICULTURAL ENGINEER desires design, development, research, sales or sales engineering and service work in farm structures field *only*, in either private industry or public service. Age 40. Salary, $4500 minimum. W-233

AGRICULTURAL ENGINEER (B.S. degree) desires sales engineering and service work in farm machinery field. Age 30. War veteran. W-234

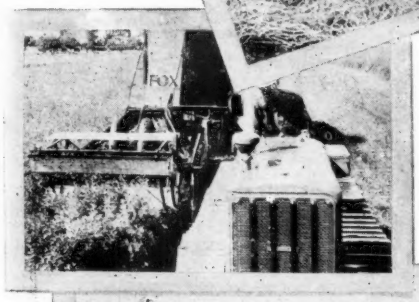
AGRICULTURAL ENGINEER (B.S. degree) desires design and development work in farm machinery or farm structures field in either private industry or public service. Age 30. Salary, $3600. W-235

AGRICULTURAL ENGINEER (B.S. degree) desires research, design, or sales engineering work in rural electrification with private company or public agency. Age 30. Salary $3200 to $3600. W-242

AGRICULTURAL ENGINEER (B.S. degree) desires service or research work in rural electrification or farm structures field with private company or government agency. Age 28. Salary $200 per month. W-243

(Continued on page 46)

The FOX will give you all "3"



THE FOX Pick-up Hay Chopper and Silage Harvester does the three toughest jobs on the farm—Haying, Forage Harvesting, and Silo Filling.

With the FOX the farm for the first time is properly mechanized because with the FOX method:

- **you can mow, chop and load in one operation over 200 tons of grass silage a day.**
- **you can cut corn of any height, chop it into silage and load it into wagons ready for the silo, all in one operation.**
- **one man, with the FOX, can pick up, chop and load, ready for the mow or stack 2 tons of dry hay in 12 minutes.**

The FOX is built by the Pioneers of Modern Forage Harvesting. WRITE US—we will be glad to tell you all about this marvelous machine.

R. C. Krueger
Secretary

FOX RIVER TRACTOR COMPANY

Pioneers of Modern Forage Harvesting

A-186 NORTH RANKIN STREET

APPLETON FOX WISCONSIN

The FOX

usually pays for itself in a short time, and unlike machines built down to a price, gives years of trouble-free service.

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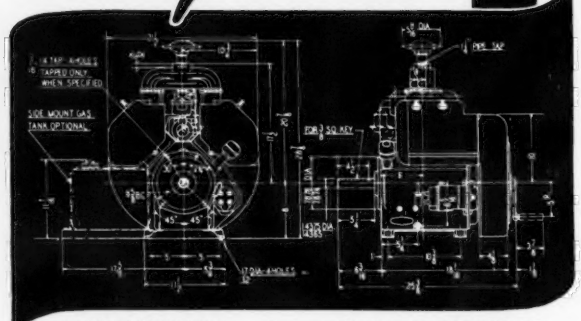
Check ✓ for SIZE



WISCONSIN Air-Cooled ENGINE

Model VE4, 22 hp., at 2600 R. P. M.

Extremely compact design is one of the outstanding virtues of Wisconsin V-type air-cooled engines. The reduction of overall engine dimensions, accomplished by V-type construction, permits easily engineered installation on almost any type of farm equipment . . . as indicated by the front and side elevation diagrams of the VE4 standard Wisconsin Engine reproduced above. This model is extensively used for powering combines and hay balers.

Don't overlook Wisconsin Air-Cooled Engines when considering integrated power for your equipment.

Most H.P. per pound

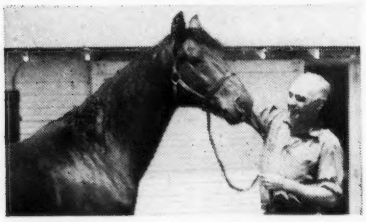
WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

GOOD FENCES

Help Turn Pasture Land Into High Yielding Farm



DEE EICHE of Lincoln, Nebraska with one of his prized riding horses

"WHEN I purchased this 80 acres 15 years ago, it was all in native range grass and badly weed-infested," says Mr. Eiche. "But after fencing into five 15-acre fields, stocking with sheep, cattle and hogs, and bringing in rotated crops and legume pasture, soil fertility and income began to improve. Last year, corn averaged 62 bu., oats 60 bu., alfalfa 3½ tons. The sheep completely cleaned up the bindweed and, thanks to good woven wire fences, I never lose a lamb to the coyotes."

NEW FENCE—present Keystone fence, though not trade-marked Red Brand, is tops in quality

KEYSTONE STEEL & WIRE COMPANY
Peoria 7, Illinois

RED BRAND FENCE
—and RED TOP STEEL POSTS—

PERSONNEL SERVICE BULLETIN

(Continued from page 44)

SALES REPRESENTATIVE, with 26 years' experience in implement and tractor fields, desires sales work with farm machinery company. Age 55. Salary open. W-246

AGRICULTURAL ENGINEER (B.S. degree) desires sales engineering and service work in power and machinery with private company. Age 30. Salary $200 to $250 per month. W-248

AGRICULTURAL ENGINEER (B.S.A. and B.S. C.E. degrees) desires design, construction, service, research or sales work in farm structures field with private company, government agency, or state college. Age 31. Salary $4200 to $4800. W-249

AGRICULTURAL GRADUATE (B.S.A. degree, major in ag eng and minor in physics) desires research, teaching, or extension work in rural electrification, farm structures, or soil and water field with state college. Age 44. Salary $2900 minimum for 9 months. W-250

AGRICULTURAL ENGINEER (B.S. degree) desires research, service or extension work in farm machinery, rural electrification, or soil and water field with private company, government agency, or college. Age 26. Salary open. W-252

AGRICULTURAL ENGINEER (B.S. and M.S. degrees in ag engineering) desires teaching and research (or extension) work in farm structures or power and machinery field with land-grant college. Age 36. Salary $3600. W-253

LANDSCAPE ENGINEER, with several years experience with state highway department, REA cooperative on construction, and construction in soil and water field, desires sales or sales promotion work in farm structures or power and machinery field. Age 35. Salary open. W-254

AGRICULTURAL ENGINEER (B.S. and M.A. degrees in agriculture and B.S. in ag engineering) desires research or research and development work with government agency or private company or teaching and research with land-grant college. Age 32. Salary $4500 to $6000. W-255

AGRICULTURAL ENGINEER (B.S. degree) desires work in research, design or development in power and machinery or soil and water field. Age 28. Salary $2500. W-257

AGRICULTURAL ENGINEER (B.S. degree) desires sales, sales engineering, or development work with private company in power and machinery or farm structures field. Age 31. Salary $3600 minimum. W-258

AGRICULTURAL ENGINEER (B.S. degree) desires design and development work with private company in farm machinery field. Age 30. Salary $325 to $350 per month. W-259

AGRICULTURAL ENGINEER (B.S. deg) desires work in rural electrn or in soil conservn with either private company or public service agency Age 25. Salary $3000 (min). W-260

AGRICULTURAL ENGINEER (B.S. deg in both agr and civil eng) desires design, development or research work (or hydrologic work requiring meteorological training and experience) in soil and water field with public service agency. Age 28. Salary $3000. W-261

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or rural development work in rural electrn, power and mach, or soil and water fields with private company or federal agency. Age 40. Salary $4200 to $5000. W-263

AGRICULTURAL ENGINEER (B.S.A. and B.A.E. degs) desires work in functional design with private company or teaching and extension work in Midwest college in the field of farm mach or farm structures. Age 26. Salary open. W-264

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or service work with farm mach company or field engineering in soil erosion control with federal agency. Age 34. Salary $4500. W-265

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work with private company in farm mach or farm structures field. Age 29. Salary open. W-266

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng work in rural electrn or farm mach with private company. Age 29. Salary $250 per mo. W-267

AGRICULTURAL ENGINEER (B.S. in agr, major in agr eng) desires development, research or sales eng work with farm mach mfr, or project eng work in soil and water field with federal agency. Age 28. Salary $3500 (min). W-268

AGRICULTURAL ENGINEER (B.S. deg) desires research, extension or design and development work in rural electrn, farm structures, or power and mach field with a public service agency. Age 28. Salary $3200. W-269

AGRICULTURAL ENGINEER (Both B.S. and M.S. degs) desires sales eng work in farm buildings or rural electrn fields with private company. Age 26. Salary $3600. W-270

AGRICULTURAL ENGINEER (B.S. deg in both agr and agr eng) desires sales eng and service work with farm mach company or irrigation or other soil conservation work with public service agency Age 27. Salary $250 per mo. W-271

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or research development work with farm mach company. Age 34. Salary $3500 (min). W-274

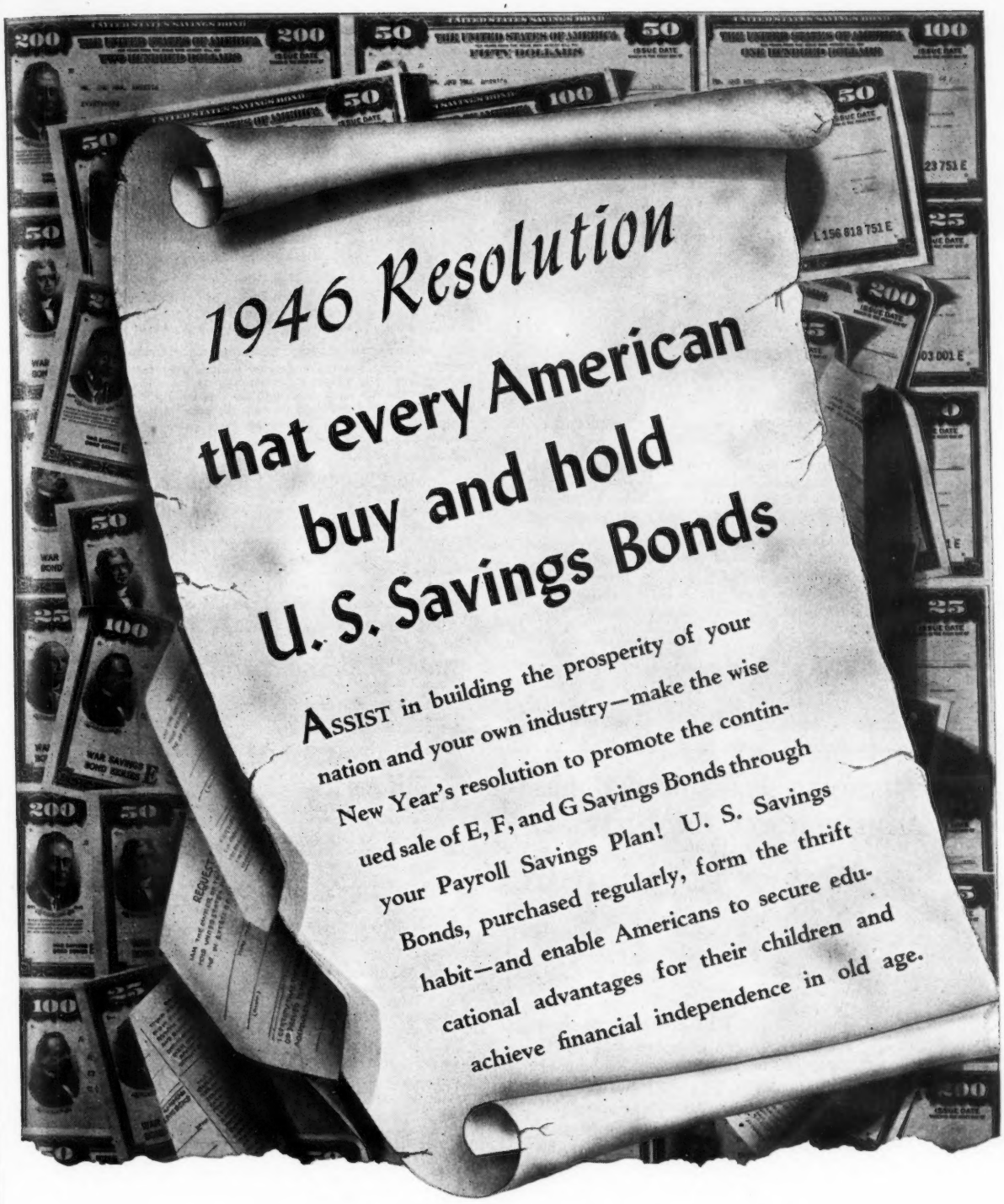
AGRICULTURAL ENGINEER (B.S. deg) desires work as development or project eng in product processing field. Age 28. Salary $3500. W-275

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work with small power and mach company. Age 24. Salary open. W-276

CHEMICAL ENGINEER (B.S. deg) desires development or sales eng work in farm mach or product processing fields. Age 43. Salary $4000 to $5000. W-277

AGRICULTURAL ENGINEER (Both B.S. and M.S. degs) desires design or development work in rural electrn or farm structures. Age 30. Salary $4000. W-278

AGRICULTURAL ENGINEER (B.S. deg) desires development or research in rural electrn with private company or public service agency, or research or extension work in soil and water (irrigation) field. Age 27. Salary $2400 to $3000. W-279 *(Continued on page 48)*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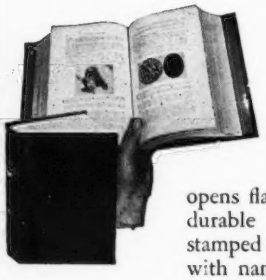

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PERSONNEL SERVICE BULLETIN

(Continued from page 46)

AGRICULTURAL ENGINEER (B.S. deg) desires design or sales eng work in power and mach fields. Age 27. Salary $3000. W-280

AGRICULTURAL ENGINEER (B.S. deg) desires research or extension work with college or federal agency in power and mach or rural electrn. Age 27. Salary $2400. W-281

AGRICULTURAL ENGINEER (B.S.A. deg) desires development or research work in power and mach, farm structures, or rural electrn field with private company or federal agency. Age 32. Salary $3500 to $4000. W-282

AGRICULTURAL ENGINEER (B.S. deg) desires research and development work in farm mach with private company or college. Age 25. Salary $3000 (min). W-283

AGRICULTURAL ENGINEER (B.S. deg) desires design, development, sales eng or research work with farm mach company. Age 27. Salary $4000 to $5000. W-284

CHEMICAL ENGINEER (B.S. deg) desires development, research, or service work in product processing field. Age 34. Salary $2000 (min). W-286

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work in farm mach or soil and water field with private company or federal agency. Age 23. Salary $2600 to $3000. W-287

AGRICULTURAL ENGINEER (B.S.A. and B.A.E. degs) desires design or research in farm mach field or research work in soil and water field. Age 27. Salary $4000. W-288

AGRICULTURAL ENGINEER (B.S.A. deg. with major in A.E.) desires sales or research work in power machinery or farm structures with private company in Florida. Age 38. Salary $3200. W-289

AGRICULTURAL ENGINEER (B.S. and M.S. degs) desires sales or service work in farm structures or power and machinery with private company in Virginia or North Carolina. Age 38. Salary $3000. W-290

AGRICULTURAL ENGINEER (B.S. deg) desires research, development, or sales engineering work with private company. Age 26. Salary $2500 to $3000. W-291

AGRICULTURAL ENGINEER (B.S. deg) desires power and machinery sales work. Age 28. Salary $3500. W-292

AGRICULTURAL ENGINEER (B.S. deg) desires power and machinery service work. Age 26. Salary $2400. W-293

AGRICULTURAL ENGINEER (B.S. deg) desires work in soil and water field. Age 30. Salary $2600. W-294

AGRICULTURAL ENGINEER (B.S. deg) desires development work in soil and water field with public agency or private company, or in research and design of power and machinery with private company. Age 25. Salary $2400. W-295

AGRICULTURAL ENGINEER (B.S. deg) desires research and development work with private company or land-grant college. Age 45. Salary open. W-296

AGRICULTURAL ENGINEER (B.S. deg) desires sales engineering or maintenance work in farm machinery or farm structures field. Age 26. Salary $3600 to $5500. W-297

UNDERGRADUATE ENGINEER, with engineering experience, desires sales work in machinery, rural electrification, or farm structures; college work or research or project engineering work in a government agency. Age 34. Salary open. W-298

AGRICULTURAL ENGINEER (B.S. deg) desires public service research, teaching, or extension work in power and machinery field. Age 26. Salary $2500. W-299

AGRICULTURAL ENGINEER (B.S. deg) desires design, development, research, sales, or service work in power and machinery field, with private company. Age 26. War veteran. Salary $200 per month. W-300

AGRICULTURAL ENGINEER (B.S. deg) desires farm structures development, sales, or service work or product processing with either a private company or public agency. Age 25. War veteran. Salary $3000. W-301